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South Asian Journal of Management Research (SAJMR), is a scholarly journal that publishes scientific research on the theory and practice of management. All management, computer science, environmental science related issues relating to strategy, entrepreneurship, innovation, technology, and organizations are covered by the journal, along with all business-related functional areas like accounting, finance, information systems, marketing, and operations. The research presented in these articles contributes to our understanding of critical issues and offers valuable insights for policymakers, practitioners, and researchers. Authors are invited to publish novel, original, empirical, and high quality research work pertaining to the recent developments & practices in all areas and disciplines.

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Dr. Pooja M. Patil

Editor

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Determinants of QR Code Payment Adoption in the Fintech Ecosystem: A Structural Equation Modelling Approach

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Abstract

Purpose – This study investigates the factors influencing the adoption of QR code payments, focusing on consumer attitudes and behaviors. It examines the role of perceived convenience, trust, and other system attributes in driving adoption. By analyzing these variables, the study seeks to offer a comprehensive understanding of how users perceive and decide to adopt QR code payment systems.

Design/methodology/approach – Data were collected through a structured survey from 159 respondents, primarily students aged 15–24. The study employed structural equation modeling (SEM) to evaluate the relationships between perceived factors and adoption intent, including model fit indices such as CFI, TLI, RMSEA, and others were analyzed to validate the proposed framework and ensure robustness of the results.

Findings – The analysis reveals that perceived convenience in payment apps (e.g., Google Pay, Paytm) is a significant positive driver of customer attitudes toward QR code adoption. Attitudes strongly mediate the relationship and in turn, strongly influence the intention to use QR code payments. While perceived usefulness, ease of use, and trust in safety also contribute significantly, other factors like perceived innovativeness and risk-free capacity play a supporting role. Demographic factors such as age, education, and occupation do not significantly affect adoption intention.

Practical implications – To promote QR code payment adoption, service providers must focus on enhancing user confidence, simplifying the payment process, and ensuring robust security. Emphasizing the seamless and risk-free nature of transactions will further boost customer trust and willingness to adopt digital payment technologies.

Originality/value – This study contributes to the growing body of literature on digital payment systems by emphasizing psychological and behavioral drivers of QR code payment adoption. The findings provide actionable insights for policymakers and app developers to optimize user experience and drive broader adoption.

Keywords -Fintech, QR code payments, Perceived confidence, User attitude, Digital payment adoption, Structural equation modelling.

Introduction

Globally, the usage of digital payment systems has expanded quickly, especially with the rise more effective and convenient payment options from consumers and the development of mobile payment technologies are the main forces behind this change. The world has witnessed an unprecedented evolution of fintech, but mostly in developed countries. The fintech revolution appears to be on track in these countries, and global legislation aims to provide full online services in the future. Users can make payments contactlessly, securely, and easily via QR code payment systems, which are supported by apps like Google Pay and Paytm. Businesses and developers looking to improve digital payment platforms must understand the elements that affect customer adoption of QR code payments.

In order to better understand the factors driving the adoption of QR code payments, this study employs structural equation modeling (SEM) to examine user attitudes and behaviors. The main focus is on how the intention to utilize QR code payment systems is influenced by perceived confidence, attitude, utility, trustworthiness, and innovativeness. Previous studies have demonstrated that customers' acceptance of QR code payments is mostly determined by their positive views toward technology adoption and their level of confidence in digital payment platforms. Furthermore, it is well recognized that elements like ease of use, safety, and the smoothness of the payment process influence customer preferences.

The results imply that perceived utility, ease of use, and trust—all of which are expectedly relevant—may not have a major effect on the uptake of QR code payments. Rather, the primary forces behind adoption, according to this research, are client attitudes and confidence as well as the general ease that QR code systems provide. This introduction lays the groundwork for a more thorough analysis of the ways in which these variables interact to affect customers' propensity to accept QR code payment systems.

Objectives

1. To evaluate how factors such as perceived use, perceived ease of use, perceived trust, perceived convenience, innovativeness and its effect on attitude.
2. To evaluate the intention to use QR code payment.

Review of Literature

Perceived Use

Research on digital payment adoption highlights its transformative potential for financial services, particularly in developing nations (Patil et al., 2017). Consistent findings show that perceived usefulness and ease of use are critical factors influencing the intention to adopt digital payment systems (Patil et al., 2017; Fazriansyah et al., 2022; Najib & Fahma, 2020). The Technology Acceptance Model (TAM) and its extended versions have been frequently applied to explore consumer behaviour toward mobile payment adoption (Patil et al., 2017; Najib & Fahma, 2020). Although perceived risk is a significant barrier to adoption (Patil et al., 2017), trust is identified as a positive driver of adoption intentions (Najib & Fahma, 2020). Demographic variables such as gender, age, profession, and income generally do not have a substantial effect on consumer attitudes toward digital payments, though education level might influence perception (Singh & Rana, 2017). For small and medium enterprises (SMEs), digital payment adoption is hindered by a lack of knowledge and resources, despite growing consumer demand (Najib & Fahma, 2020).

Perceived Ease of Use

Research on digital payment adoption consistently highlights perceived ease of use (PEOU) as a significant factor influencing consumer behaviour. Multiple studies have found that PEOU positively affects the intention to use digital payment platforms (Fazriansyah et al., 2022; Siagian et al., 2022). PEOU also indirectly influences behavioural intention through perceived usefulness (Siagian et al., 2022). Additionally, perceived usefulness and performance expectancy are identified as key determinants of adoption intention (Patil et al., 2017; Fazriansyah et al., 2022). Trust and perceived security play crucial roles in shaping consumer behaviour towards digital payments (Siagian et al., 2022). Despite the potential benefits, adoption rates remain low in some regions, necessitating further investigation into factors like consumer innovativeness (Singh et al., 2018). Understanding these factors can help businesses and governments develop strategies to promote digital wallet adoption and foster a cashless economy (Singh et al., 2018).

Perceived Trust

The adoption of digital payment services is influenced by several key factors, with trust playing a central mediating role (Kurniasari, 2021; Purwantini & Anisa, 2021; Kantika et al., 2022; Nguyen & Huynh, 2018). Security concerns and perceived risk significantly impact trust formation and adoption intentions (Kurniasari, 2021; Purwantini & Anisa, 2021). Interestingly, perceived risk can have both positive and negative effects on adoption, depending on the context (Purwantini & Anisa, 2021; Nguyen & Huynh, 2018). Other factors influencing adoption include perceived usefulness, perceived enjoyment, financial literacy, and brand image (Purwantini & Anisa, 2021; Kantika et al., 2022). For digital banks, which lack physical branches, building trust is particularly crucial (Kantika et al., 2022). To increase user trust and adoption, companies should focus on enhancing IT resources, developing attractive platforms, and cultivating a positive industry image (Kantika et al., 2022). These findings highlight the complex interplay of factors affecting digital payment adoption, with trust and risk perception playing pivotal roles.

Innovativeness

Recent studies have explored the factors influencing digital payment adoption, with a focus on consumer innovativeness. A meta-analysis revealed that attitude, cost, mobility, and innovativeness significantly affect behavioural intentions to adopt digital payment methods (Patil et al., 2018). Consumer innovativeness has been identified as a key construct in reducing perceived risk and improving digital banking adoption (Borah & Chaudhary, 2024). Similarly, innovativeness and perceived ease of use play crucial roles in the adoption of digital wallets in India (Singh et al., 2018). Trust has also been found to mediate the relationship between personal innovativeness, security concerns, and perceived enjoyment in digital payment adoption (Kurniasari, 2021). These studies collectively highlight the importance of consumer innovativeness in driving digital payment adoption across various contexts, suggesting that financial institutions and policymakers should consider this factor when developing strategies to promote digital payment solutions.

Perceived Convenience

Digital payment adoption has been extensively studied using various theoretical frameworks, with TAM and UTAUT being the most commonly applied models (Patil et al., 2017; Colline et al., 2022; Susanto et al., 2022). Perceived usefulness and ease of use are significant drivers of adoption intention, while perceived risk acts as a major inhibitor (Patil et al., 2017). Security is frequently identified as a crucial factor in digital payment adoption (Colline et al., 2022). Other influential factors include trust, satisfaction, social influences, and facilitation conditions (Susanto et al., 2022). Demographic factors such as gender, age, profession, and income generally do not significantly impact consumer perception, although education level may influence adoption (Singh & Rana, 2017). Digital payments offer convenience to users across generations, from Gen Z to Baby

Boomers (Colline et al., 2022). The expansion of internet networks and mobile technology has contributed to the growth of digital payment systems, particularly in Asian countries (Susanto et al., 2022).

Attitude

The adoption of digital payment systems is influenced by various factors, with attitude playing a crucial role in mediating the impact of perceived benefits and trust on adoption intentions (Murpin Josua Sembiring et al., 2022). A meta-analysis confirmed the significant cumulative effects of attitude, cost, mobility, and innovativeness on behavioural intentions to adopt digital payment methods (Pushp P. Patil et al., 2018). The extended Technology Acceptance Model (TAM) has been applied to investigate adoption factors, revealing that perceived ease of use, perceived usefulness, attitude, and trust determine the intention to use digital payments (M. Najib & F. Fahma, 2020). As economies shift towards cashless transactions, consumers are increasingly using digital payment instruments such as debit/credit cards, digital wallets, net banking, and mobile payment applications (Shailza & Madhulika P. Sarkar, 2019). However, small and medium enterprises (SMEs) face challenges in adopting these technologies due to limited knowledge and resources (M. Najib & F. Fahma, 2020).

Intention to Use

Digital payment adoption has been studied extensively, with researchers examining various factors influencing users' intentions to adopt these systems. Performance expectancy and perceived usefulness have been identified as the most significant determinants of behavioural intention to use mobile payments (Patil et al., 2017). The Unified Theory of Acceptance and Use of Technology (UTAUT) model has been widely employed in these studies, often with extensions to include additional constructs (Jain & Chowdhary, 2021; Chaveesuk et al., 2021). Factors such as facilitating conditions, perceived ease of use, and attitude have been found to influence adoption intentions (Jain & Chowdhary, 2021; Chaveesuk et al., 2021). Perceived risk has been identified as a major inhibitor to mobile payment adoption (Patil et al., 2017; Chaveesuk et al., 2021). The COVID-19 pandemic has also impacted digital payment adoption, with social distancing becoming a relevant factor (Chaveesuk et al., 2021). These studies have implications for developing economies and financial institutions in promoting digital payment systems (Siddiqui & Khan, 2019; Chaveesuk et al., 2021).

HYPOTHESIS DEVELOPMENT

HO1: There is no significant relationship between perceived usefulness and the attitude

HO2: There is no significant relationship between perceived ease of use and the attitude

HO3: There is no significant relationship between perceived trust towards the attitude

HO4: There is no significant relationship between innovativeness and the attitude

HO5: There is no significant relationship between perceived convenience towards the attitude

HO6: There is no significant relationship between the attitude and the intention to use

HO7: There is no significant relationship between place of residence and intention to use.

Methodology

The researcher used descriptive research with convenience sampling as the sampling tool to collect the data. The researcher adopted existing scales to measure the variables such as perceived trust (Gao et al., 2011), perceived use (Gao et al., 2011), perceived ease of use (Gao et al., 2011), perceived convenience (Pham et al., 2018b), innovativeness (Rojas-Méndez et al., 2015), attitude (Kwek Choon Ling et al., 2010) and intention to use (Gao et al., 2011). The data was collected from 172 sample elements. The researcher used Structural equation modelling for data analysis with SPSS 21 and AMOS 24. The reliability values Cronbach alpha of all constructs was above 0.7, and this indicates that the construct reliability is pretty good.

TABLE 4.1
Demographic analysis
Statistics

	AGE	GENDER	MARITAL STATUS	EDUCATIONAL QUALIFICATION	OCCUPATION	Place of Residence
N	159	159	159	159	159	159
Valid	0	0	0	0	0	0
Missing	0	0	0	0	0	0
Mean	1.327	1.623	1.767	3.214	4.365	2.057
Std. Deviation	.6213	.4863	.4239	.7661	1.2140	.8286

AGE			
		Frequency	Percent
Valid	15-24	119	74.8
	25-35	29	18.2
	36-45	10	6.3
	46-55	1	.6
GENDER			
		Frequency	Percent
Valid	FEMALE	60	37.7
	MALE	99	62.3
MARITAL STATUS			
		Frequency	Percent
Valid	MARRIED	37	23.3
	UNMARRIED	122	76.7
EDUCATIONAL QUALIFICATION			
		Frequency	Percent
Valid	HIGHER SECONDARY	31	19.5
	GRADUATE	65	40.9
	POST GRADUATE	61	38.4
	PhD	2	1.3
OCCUPATION			
		Frequency	Percent
Valid	SELF EMPLOYED	1	.6
	PRIVATE EMPLOYEE	30	18.9
	GOVERNMENT EMPLOYEE	2	1.3
	4.0	3	1.9
	STUDENT	123	77.4
Place of Residence			
		Frequency	Percent
Valid	URBAN	50	31.4
	RURAL	50	31.4
	SEMI-URBAN	59	37.1
	Total	159	100.0

Results

The demographic information sheds light on the 159 valid respondents that make up the study's sample population. Participants' ages range from 15 to 24 years old on average, as seen by their mean age score of 1.327 and standard deviation of 0.6213. The age range of the bulk of respondents (74.8%) is 15–24, followed by 25–35 (18.2%), and older age groups comprise a relatively minor fraction of the sample.

With a mean gender score of 1.623, the distribution of respondents' genders is as follows: 62.3% are men and 37.7% are women. The mean marital status score of 1.767 indicates that just 23.3% of participants are married, while the majority of participants—76.7%—are single.

The respondents' educational backgrounds are diverse; the majority (40.9%) have graduate degrees, followed by postgraduates (38.4%) and higher secondary school graduates (19.5%). The mean score for educational qualification is 3.214, with a tiny percentage (1.3%) holding a PhD. Regarding occupation, students make up the majority of the sample (77.4%), with private employees making up 18.9% of the respondents. A minor portion of the sample consists of other occupational categories, such as self-employed people (0.6%) and government employees (1.3%). The majority of students in the dataset are reflected in the mean occupation score of 4.365.

Finally, there is an equal distribution of participants' places of residence: 31.4% come from both rural and urban areas, and 37.1% live in semi-urban areas. With a mean place of residence score of 2.057, the distribution of the various types of dwelling locations is adequately balanced.

In general, the sample is made up mostly of students, is pretty evenly distributed throughout urban, rural, and semi-urban areas, and is largely male, unmarried, well-educated, and relatively young.

Structural Equation Model

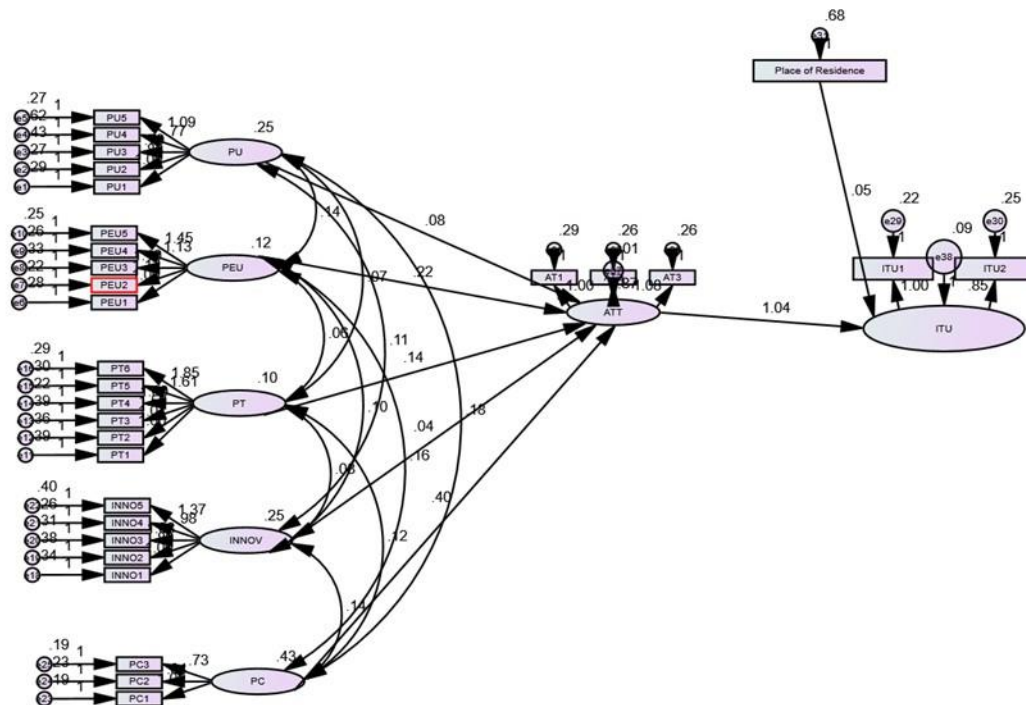


Table 5.1

Model	NPAR	CMIN	DF	P	CMIN/DF
	76	649.167	389	0	1.669
	RMR	GFI	AGFI	PGFI	
	0.04	0.8	0.761	0.669	
	NFI	RFI	IFI	TLI	CFI
	Delta1	rho1	Delta2	rho2	
	0.692	0.656	0.849	0.826	0.844

The model fit indices presented for the QR code adoption study indicate a generally acceptable fit between the proposed model and the observed data. The Chi-square (CMIN) value of 649.167 with 389 degrees of freedom (DF) and a p-value of 0 suggests that while the model is statistically significant, the ratio of CMIN/DF is 1.669, which falls below the threshold of 3, indicating a good fit.

The Root Mean Square Residual (RMR) value is 0.04, indicating a relatively low level of residual errors, further supporting a good model fit. However, the Goodness-of-Fit Index (GFI) is 0.8, and the Adjusted Goodness-of-Fit Index (AGFI) is 0.761. The Parsimonious Goodness-of-Fit Index (PGFI) is 0.669, reflecting the model's simplicity, though it is lower than the desired range for parsimonious models.

The Normed Fit Index (NFI) of 0.692 and the Relative Fit Index (RFI) of 0.656 are somewhat indicating moderate fit. In contrast, the Incremental Fit Index (IFI) at 0.849, Tucker-Lewis Index (TLI) at 0.826, and Comparative Fit Index (CFI) at 0.844 suggest that the model fits the data reasonably well and it shows a good fit.

Table 5.2 Showing the Results of Direct Effects

			Estimate	S.E.	C.R.	P	Label
ATTITUDE (F6)	<---	PERCEIVED USEFULNESS(F1)	.076	.154	.492	.623	NOT SIGNIFICANT
ATTITUDE	<---	PERCEIVED EASE OF USE(F2)	.218	.302	.722	.471	NOT SIGNIFICANT
ATTITUDE	<---	PERCEIVED TRUST(F3)	.145	.117	1.239	.216	NOT SIGNIFICANT
ATTITUDE	<---	INNOVATIVENESS(F4)	.042	.075	.555	.579	NOT SIGNIFICANT
ATTITUDE	<---	PERCEIVED CONVENIENCE(F5)	.396	.088	4.502	***	SIGNIFICANT
ITU (INTENTION TO USE)	<---	ATTITUDE	1.042	.171	6.090	***	SIGNIFICANT
ITU	<---	Place of Residence	.055	.048	1.140	.254	NOT SIGNIFICANT

From the SEM results, it is evident that the perceived convenience of the customers is one of the significant positive factors that influence the attitude of the customers to adopt the QR code payment with a β value of 0.396, $p < 0.000$. The customer's convenience in payment apps like Google Pay, Paytm, etc. creates a positive attitude towards the adoption of such digital payments.

The attitude of the customers strongly influences the intention to use the QR code payments with a β value of 1.042, $p < 0.000$. This indicates that the customer's attitude significantly influences their positive mindset towards the adoption of QR code payments, and they also anticipate using digital cash.

All other factors, including perceived usefulness, perceived ease of use, perceived trust, and innovativeness, do not significantly influence the attitude of customers when considering their willingness to adopt QR code payments. The customer's location has no role in generating an intention to adopt the QR code payment option.

According to the findings of the structural equation modelling (SEM) study, it is evident that the customers' perceived convenience in QR code payments is a significant positive aspect that influences their attitude towards embracing this technology. This self-assurance, in particular with regard to well-known payment applications, has a beneficial impact on their willingness to accommodate digital payment methods.

The attitudes of customers, on the other hand, have a significant impact on the likelihood that they will use QR code payments. Consequently, this indicates that a positive attitude plays a crucial role in contributing to their favorable outlook towards the adoption of QR codes and their anticipation of employing digital payment technologies.

Table 5.3: Standardised Regression Weights

PU1	<---	Perceived usefulness	1.000			
PU2	<---	Perceived usefulness	.881	.128	6.879	***
PU3	<---	Perceived usefulness	.789	.140	5.625	***
PU4	<---	Perceived usefulness	.773	.159	4.856	***
PU5	<---	Perceived usefulness	1.090	.145	7.502	***
PEU1	<---	Perceived Ease of Use	1.000			
PEU2	<---	Perceived Ease of Use	1.115	.192	5.812	***
PEU3	<---	Perceived Ease of Use	1.102	.207	5.313	***
PEU4	<---	Perceived Ease of Use	1.132	.201	5.637	***
PEU5	<---	Perceived Ease of Use	1.447	.234	6.194	***
PT1	<---	Perceived Trust	1.000			
PT2	<---	Perceived Trust	1.014	.238	4.259	***
PT3	<---	Perceived Trust	1.592	.322	4.944	***
PT4	<---	Perceived Trust	1.599	.305	5.248	***
PT5	<---	Perceived Trust	1.610	.315	5.108	***
PT6	<---	Perceived Trust	1.848	.352	5.255	***
INNO1	<---	Innovativeness	1.000			
INNO2	<---	Innovativeness	.800	.139	5.769	***
INNO3	<---	Innovativeness	1.079	.154	6.996	***
INNO4	<---	Innovativeness	.975	.139	6.995	***
INNO5	<---	Innovativeness	1.371	.189	7.267	***
PC1	<---	Perceived Convenience	1.000			
PC2	<---	Perceived Convenience	.836	.084	9.975	***
PC3	<---	Perceived Convenience	.731	.075	9.810	***
AT1	<---	Perceived Convenience	1.000			
AT2	<---	Perceived Convenience	.868	.150	5.803	***
AT3	<---	Perceived Convenience	1.080	.167	6.484	***
ITU1	<---	Intention to use	1.000			
ITU2	<---	Intention to use	.852	.132	6.431	***

The perceived usefulness of QR code adoption is significantly influenced by the system's ability to find bar codes for easy payment, with a β value of 0.881, $p < 0.000$. The customer's perception of the usefulness of QR code adoption is significantly influenced by the ease of scanning the code using mobile devices or other gadgets. With a β value of 1.090, $p < 0.000$, customers look for the usefulness of QR code payments and ensure that it meets their immediate need or requirement.

One of the primary factors encouraging users to adopt QR code payments for in-person payments is their perceived ease of use. Customers need the system to be flexible to interact with, which enables them to use it to meet necessities without any technical glitches with a β value of 1.132, $p < 0.000$. The user-friendliness of the QR code also plays an important role in adopting it, with a β value of 1.447, $p < 0.000$.

The perceived trust of the QR code system is another factor that enables the user to trust it in making the payments. The safety of the QR code system is one important factor in its adoption; higher safety leads to more usage with a β value of 1.848, $p < 0.000$. The customers also look for the risk-free capacity of the QR code system to make payments through it, as less risk-associated payments make them more convenient to use with a β value of 1.610, $p < 0.000$.

Another factor that encourages user adoption is the innovativeness and functionality of the payment apps. The customers face fewer problems than other people in making technology work, and this improves the innovativeness with a β value of 1.079, $p < 0.000$. The customer's awareness and readiness to adopt the new technologies in the introduction stage is also one crucial element in bringing innovativeness with a β value of 1.371, $p < 0.000$. They consider themselves innovative compared to their friend circle, and that brings them better status.

Users adopt QR code payments due to their convenience; the flexibility of UPI apps and QR code scanning systems significantly contribute to this adoption. The customer's access at the point of sale greatly influences their intention to use such payment modes.

The users' perception of the system's capacity to locate and process barcodes for payment in an effective manner is a significant factor that plays a significant role in the adoption of QR code payment systems. Customers are looking for a seamless experience that satisfies their immediate requirements, and they place a substantial amount of value on the ease with which they may search for codes using their mobile devices. The ease of use that is thought to be associated with QR code payments is one of the primary elements that is pushing their adoption. Customers anticipate that the system will run without any technical concerns, which will improve their entire experience. Therefore, the system's adaptability and user-friendliness are of the utmost importance.

Trust in the QR code payment system is another important factor that contributes to its widespread acceptance. Higher levels of perceived security are associated with an increase in the likelihood that customers will use these systems. Customers place a high priority on the safety and dependability of these systems. As a result of the fact that customers are more likely to utilize the system when they perceive lesser risks associated with the payment process, the capability of the system to deliver risk-free transactions is a significant factor.

Furthermore, the innovativeness and functionality of payment applications are factors that lead to the acceptance of these applications by users. It is more probable that customers will enjoy the unique qualities of the technology if they experience fewer technical hurdles. As a result of the fact that certain users perceive themselves to be more technologically sophisticated in comparison to their peers, the adoption of QR code payments is associated with a higher social standing. This is because awareness and readiness to accept new technologies further strengthen the perception of innovativeness.

A further key factor that encourages people to adopt QR code payments is the convenience it provides. Customers' intentions to use these payment methods are heavily influenced by a number of factors, including the adaptability of UPI apps and the simplicity of QR code reading at points of sale. The availability of these technologies at the time of purchase is another factor that increases the chance of their deployment.

Discussion and Conclusion

The structural equation modeling (SEM) analysis results provide important insights into the elements that influence the adoption of QR code payment systems. Specifically, the users' perceived convenience in payment applications such as Google Pay and Paytm appears as a strong positive factor, which fosters a favorable attitude towards the adoption of QR code payment. The customers' readiness to embrace QR code technology is directly impacted by their convenience in digital payment platforms.

According to the findings of the study, the views of customers have a substantial impact on their interest in adopting QR code payment practices. There is a substantial correlation between having a positive attitude and having a favorable outlook on the adoption of digital payment methods, both of which indicate an important psychological aspect in their decision-making process. In contrast to what was anticipated, it was discovered that other aspects, such as perceived usefulness, convenience of use, trustworthiness, and innovativeness, did not have a major impact on the preferences of customers for the implementation of QR code payments.

In addition, the data suggest that the degree to which customers believe they can trust the safety and dependability of QR code payment systems is a significant factor in the rate of widespread adoption. Increased levels of perceived safety and decreased dangers connected with using QR code payments have a beneficial impact on the likelihood that users will utilize these payments. To further improve their positive attitude towards QR code payments, customers who regard themselves to be tech-savvy and inventive are more likely to accept new technologies. This is because they are more likely to see the benefits of these technologies.

Last but not least, the ease of use of QR code payments, in conjunction with the adaptability of UPI apps and the simplicity of scanning codes at points of sale, emerges as a crucial factor that increases the likelihood of user acceptance. The availability of such payment methods at the moment of purchase is another factor that influences customers' inclination to use them, which further emphasizes the role that convenience plays in

promoting adoption. Generally speaking, the variables that are most important in determining how customers behave about the adoption of QR code payment are confidence, attitude, trust, and convenience.

Implications and Future Research Directions

As QR code payments often integrate with AI, AR, or IoT in fintech, future research could explore how these technologies impact consumer trust and acceptance of QR-based systems, especially in highly digital ecosystems. Study the psychological and social factors that contribute to QR code payment adoption, such as social influence, peer usage, or brand image. This can further clarify how word-of-mouth and peer networks drive adoption. With QR codes serving as a gateway for embedded payments, future studies could explore the broader consumer dynamics within this domain, such as preferences, switching behavior, and the integration of payment options within everyday services.

Limitations

The first limitation is the context in which this research was carried out in. As such, the results might not accurately match the QR code payment adoption scene in other countries as the differentiation between countries is aplenty. Hence, researchers could consider including data from multiple countries by conducting a cross-country study. Secondly, this study has only focused on the QR code payment verticals. Therefore, further researchers can consider comparative studies that analyse different payment options available.

Declaration

We, hereby declare that the research work entitled "Determinants of QR Code Payment Adoption in the Fintech Ecosystem: A Structural Equation Modelling Approach" is our original work. It has been conducted and prepared by us, and have not submitted it, in whole or in part, to any other institution or organization for any academic degree, diploma, or certificate. We affirm that this work is free from any form of plagiarism, and all sources used or quoted have been appropriately acknowledged and cited.

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Perception of Indian Customers towards Ai-Powered CRM Practices Implemented In E-Commerce Companies

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Abstract

The use of Artificial Intelligence (AI) in Customer Relationship Management (CRM) systems has revolutionized the way organizations examine their extensive customer data. Organizations are enhancing their ability to adapt to the AI customer service system (AICS) and digitalization environment by developing skills and processes to increase their agility. They help to optimize and personalize customer interactions, predict trends in customer behaviour and improve operational efficiency. AI has ushered in a new era in Customer Relationship Management that embrace AI in their CRM systems can gain a competitive edge by offering highly personalized and efficient customer interactions. This study investigates the influence of customer satisfaction on the implementation of Artificial Intelligence (AI) in Customer Relationship Management (CRM) within e-commerce enterprises. This study utilizes pre-existing research to formulate hypotheses and construct a conceptual framework. The primary objective of this study is to understand Indian customers' perceptions of AI-powered CRM practices in e-commerce companies. This study gives importance to customers' prepositions towards satisfaction regarding AI enabled CRM practices in Indian context. The model is empirically validated by investigating Indian consumers using a Stratified Random Sampling technique for selecting the respondents. The sample of 662 Indian customers was surveyed through questionnaire to collect insights on their experience and perceptions of AI enhanced CRM practices. Data were analyzed using descriptive and inferential statistics with thematic analysis applied to qualitative responses. The statistical analysis is performed using partial least squares Structural Equation Modelling (PLS-SEM). The findings, when considered in the context of organizational agility, demonstrate that the perceived value and simplicity of the use of AICS, employee trust and attitude, and behavioural intention are important factors that mediate the adoption of AICS. This study finds that there is a significant correlation between Customer Loyalty and positive outcomes like satisfaction. AI assisted CRM practices have significantly impacted in e-commerce sector in execution of tasks and Customer satisfaction. The findings have evident practical implications and avenues for further research.

Keywords: Artificial Intelligence, Customer Relationship Management, Customer Satisfaction, Organizational Agility, Indian Context.

Introduction

Six business principles Customer Value (CV), Customer Acquisition (CA), Customer Retention (CR), Customer Interaction (CI), Product Management (PM), and satisfaction of customers regarding AI-enabled CRM systems underpin this study. Businesses are customer-centric (focus), increasingly dependent on technology (means), and in an ever-changing and unpredictable environment that demands attitudinal and procedural agility to change quickly and effectively for competitive advantage. This research covers Indian customer prepositions towards satisfaction regarding Artificial Intelligence (AI) enabled Customer Relationship Management (CRM) systems. This paper explores the integration of Artificial Intelligence into Customer Relationship Management systems within the framework of organizational agility. It focuses on the interaction of three key business concepts: CRM, e-commerce models and AI. This paper aims to assess the value and impact of these concepts on knowledge and practice in the Indian context.

Client Relationship Management (CRM) necessitates meticulous analysis of client data (Chatterjee et al., 2021). Companies engage in this practice to get the most efficient and effective use of data. AI must reliably and cost-effectively store and analyze massive amounts of client data to enable businesses to succeed (Gnizy, 2019). CRM AI may be enough in stable business environment. Organizations need to adapt their procedures and outlook towards adoption to stay competitive in a dynamic business environment. Thus, we must understand how agility and AI customer service systems give firms an edge (Chatterjee et al., 2021).

In today's competitive business environment, organizations must improve their operations, products and services. Organizations must seize opportunities and adapt quickly in an unpredictable climate. Organizational agility drives success across industries, locations and enterprises. To be agile, organizations must collect, analyze, assess and utilize large amounts of customer data for CRM (Chatterjee et al., 2020; Nguyen and Mutum, 2012; San-Martina et al., 2016)). AI is helping overcome the large volume of data that limits its use

(Eriksson et al., 2020; Stone, 2020). AI-integrated CRM systems (AICS) simplify and minimize the cost of customer data analysis (Chan et al., 2019; Vrontis, 2017).

User experiences have expanded with AI, from physical stores to websites to chatbots to voice assistants. This study by Suresh and Rani (2020); Bedi and Singh (2022) in the Indian context found factors affecting consumer perception of e-commerce and its applications, such as personalized shopping experiences for online buyers, real-time product targeting, visual search, AI-based hiring processes, voice-powered search, assortment intelligence tools, conversational commerce, customer service, virtual personal shoppers, virtual assistants, AI fake review detection, AI-based sales processes and customer satisfaction.

AI-integrated CRM system adoption and organizational agility demand adaptation, innovation and resilience to maximize the commercial potential (Nazir and Pinsonneault, 2012; Santoro et al., 2019, Holbeche, 2018; Shams et al., 2020). Organizational ambidexterity is also important (Akthar et al., 2018; Vrontis, 2017).

According to McKinsey Global Institute (2022) AI adoption and use survey less than 20 % of Indian retail firms are adopting one or more technologies at scale or in a core part of their business, weighted by firm size, despite the opportunities it has. Though the Indian retail sector was an early adoption of AI technologies for customized suggestions, preference-based browsing and image-based product search. Customer demand prediction, inventory management and delivery efficiency are further use cases (NITI Aayog, 2018). However, the effect of AI on the implementation of CRM in e-commerce companies and its impact on Indian consumer satisfaction, perceived value, retention, acquisition, intention and product management is not been vividly discussed, which is deemed important to know because per Accenture report (2017), India's AI has the potential to add 1 trillion to its economy by 2035. Thus, the opportunity that lies ahead, and the gravity of the situation intend the researcher to investigate the impact of customer satisfaction on Artificial Intelligence (AI) towards the CRM implementation in e-commerce companies.

Objectives of the Study

The goal of the study is to investigate the influence of Customer Satisfaction on the implementation of Artificial Intelligence (AI) in Customer Relationship Management (CRM) Practices within e-commerce enterprises among Indian customers.

Research Questions

AI-integrated CRM systems and client satisfaction after adoption are inconsistent (Jagtap and Duong, 2019; Osei et al., 2019). Minimal research exists on optimization and agility- AICS (Osei et al., 2019). Therefore, the study will bridge the gap by framing the following research questions.

1. To what extent does customer interaction influence satisfaction with Artificial Intelligence (AI) towards CRM implementation in e-commerce companies?
2. To what extent does customer retention influence satisfaction on AI towards the CRM implementation in e-commerce companies?
3. To what extent does customer acquisition influence satisfaction with Artificial Intelligence towards the CRM implementation in e-commerce companies?
4. To what extent does product management influence satisfaction with Artificial Intelligence towards the CRM implementation in e-commerce companies?
5. To what extent does customer value influence satisfaction on Artificial Intelligence towards the CRM implementation in e-commerce companies?
6. To what extent does customer satisfaction influence AI-enabled CRM implementation in e-commerce companies?

Literature Review

Relationship of Customer Satisfaction with AI-enabled CRM Implementation

Customer happiness is crucial for integrating AI-powered CRM into e-commerce businesses. Studies like (Antonio et al., 2022) indicate that using Chabot in customer service systems can reduce expenses, but it may also diminish customer satisfaction because of factors like inadequate responses and robotic interactions. Customer happiness is considered a key factor in Chabot engagements, along with privacy, dependability, personalization and reactivity (Srivastava, 2021). It has been suggested that we use a customer satisfaction model based on Expectation Confirmation Theory (ECT) and Uncertainty Reduction Theory (URT) to look into how Chabot in AI-enabled CRM in e-commerce affect the happiness of users (Sohail et al., 2021). Additional study is required to tackle difficulties and enhance customer satisfaction in Chabot engagements and AI-enabled CRM implementation: the same has also been asked by Pillarisetty and Mishra (2022). Thus, it is hypothesized;

H1: Customer satisfaction has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Relationship of Customer value and Artificial Intelligence towards the CRM Implementation

Customer value is essential for incorporating AI-powered CRM in e-commerce companies. Implementing AI in web development improves the client experience through personalized services, leading to increased customer satisfaction and loyalty (Thandekkattu and Kalaiarasi, 2022). CRM tactics, including consumer connection management and trust-building techniques are designed to improve long-term customer value and reinforce relationships with consumers (Roba and Maric, 2023; Detscher and Stoll, 2021). AI-powered solutions like as virtual personal stylists, Chabot and and recommendation engines enhance the customer journey and improve the overall consumer experience in online fashion websites. The shift from transactional to relationship-focused approaches in e-commerce emphasizes the importance of customer satisfaction and enjoyment, achieved through comprehensive e-CRM methods and the use of intelligent agents (Pani and Venugopal, 2008). Chen et al.'s study shows that AI Chabot, a type of AI-powered CRM, improves the online customer experience and satisfaction in e-retailing according to Schoder and Madeja (2004). Schoder and Madeja's study highlighted that Electronic Commerce Customer Relationship Management (ECCRM) is a crucial element for success in electronic commerce, especially for B2C and small enterprises, as noted by Chang and Weng in 2012. These findings indicate that customer value is essential for driving the installation and success of AI-enabled CRM systems in e-commerce enterprises; however, the driving factors of consumer value remain unidentified. Thus, to investigate the relationship of consumers of India as a market, it is hypothesized:

H2: Customer value has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Relationship of Product Management with AI-enabled CRM Implementation

Product management, which encompasses content management systems, order management and shipment has a substantial impact on the integration of AI-powered CRM in e-commerce firms. Efficient product management guarantees the availability of essential data and information for AI systems to analyze and make well-informed judgements (Amroush et al., 2008). The content management system enables the effective organization and retrieval of pertinent knowledge, which is essential for AI algorithms to analyze and produce insights. Order management and shipment systems help streamline client orders and deliveries, allowing AI-powered CRM to offer customized and punctual customer interactions. The user's text is empty (Gatla et al., 2022). Integrating AI with legacy CRM systems in B2C relationships helps improve Customer Relationship Management by analyzing enormous amounts of data automatically (Chatterjee et al., 2022). However, the results have shown mixed results; also the context has not been much studied in the Indian context, to bridge the literature gap. It is hypothesizes that:

H3: Product Management has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Relationship of Customer Acquisition with AI-enabled CRM Implementation

Customer acquisition, search engine capabilities and data accuracy are crucial factors that impact the integration of AI-powered CRM in e-commerce businesses (Chatterjee et al., 2022; Jayanti et al., 2022). Integrating AI with current CRM systems enables the analysis of extensive data sets autonomously, proving to be a great asset for managing customer relationships (Muhammad and Permana, 2019). The effectiveness of AI-CRM implementation relies on aspects including information quality, system fit and organizational fit, which have a substantial and positive influence on the adoption of AI-CRM for B2C relationship management (Ahmed, Amroush and Maati, 2016). Technology turbulence can influence the adoption and success of AI-CRM capacity within the organization (Becker, Greve and Albers, 2009). High-quality customer data is essential for enhancing organizations' comprehension of their clients and delivering optimal online service. Customer acquisition methods, such as search engine capabilities and data quality, are crucial for the effective integration of AI-powered CRM in e-commerce firms (Wqandoko and Panggati, 2022), however, the behaviour of Indian consumers towards AI-enabled CRM implementation is not clear, thus, it is hypothesized.

H4: Customer Acquisition has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Relationship of Customer Retention with AI-enabled CRM Implementation

Customer retention is crucial for organizations to thrive in mature industries (Nagaraj et al., 2023). Utilizing AI in customer service can enhance organizational efficiency, but inadequate customization may result in dissatisfaction (Nataraj, 2010). Hence, e-commerce firms should prioritise enhancing the customer experience with AI-powered services like personalized communication and recognition to maintain customer

loyalty/retention (Das et al., 2018; Ibrahim et al., 2020). AI integration in CRM systems helps forecast customer loss and can be used to enhance client retention. Customer retention, strong CRM strategies, and AI enabled technology are essential for e-commerce enterprises to thrive in the competitive market. Thus, it is hypothesized:

H5: Customer Retention has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Relationship of Customer Interaction with AI-enabled CRM Implementation

Customer engagement, encompassing customer interaction management, social media utilization and multimedia characteristics, significantly impacts the integration of AI-powered CRM in e-commerce firms. Integrating AI with CRM systems enhances customer experiences and enables personalized interactions (Alzahrani, 2016; Krishnareddy et al., 2022). Social media technology positively impacts firms' distribution chain interactions, boosting customer experiences and improving CRM outcomes (Krishnareddy et al., 2022). Moreover, integrating Chatbot into CRM systems allows organizations to deliver efficient and customized customer experiences by automating processes and choices (Chatterjee et al., 2022). Effective deployment of AI-incorporated CRM systems necessitates meticulous planning, considering aspects like data quality, system compatibility and organizational alignment (Roba and Maric, 2023). Customer engagement, Incorporating social media and multimedia elements, is essential for promoting the use and effectiveness of AI-powered CRM in e-commerce businesses (Dhanesh and Duthler, 2019). Thus, it is hypothesized:

H6: Customer Interaction has a positive influence towards AI-enabled CRM implementation in e-commerce companies.

Research Methodology

Primary Data

In this study primary data was collected through online survey which is distributed to 700 Indian customers. Respondents were asked about their experiences with AI-powered CRM systems, focusing on how satisfied they were with personalized recommendations, customer support and privacy concerns. The survey used a Likert scale for quantitative questions (1 to 5) and open-ended questions for qualitative insights. Emphasizes were made since the start towards the importance of avoiding complex or leading questions in the questionnaire. Attention was also given to the fact that the potential respondents did not have any problems understanding the questions. All these attempts were taken to increase the response rate (Chidlow et al., 2015). The layout of the questionnaire was in order and no leading or ambiguous questions were set. The questionnaire was prepared according to the scale development procedure (Carpenter, 2018). The items were prepared in the form of statements and the respondents were asked to reply by selecting the best option. A 5-point Likert scale was used, ranging from Strongly Disagree (SD) to Strongly Agree (SA). Out of 700 respondents, 662 Indian customers had a 94.57 % response rate using a Stratified Random Sampling method. Given this high response rate, it was not perceived as essential to perform a non-response bias test (Armstrong and Overton, 1977). The number of items and respondent ratio should lie between 1:4 and 1:10 (Deb and David, 2014; Hinkin, 1995). As such, the responses are within standard acceptable limits. The number of responses by type of organization is discussed in the results section. Participants and procedure using the ideas of constructs and theories that are already out there, 54 measurement items were made for the survey to use the partial least squares Structural Equation Modeling (PLS-SEM) method to check the conceptual model (Figure 1) and 12 questions were asked by the respondents based on the Demographic profiling. Since the conceptual model says that there are more independent variables than dependent variables, PLS-SEM analysis was used to test the hypotheses and confirm the conceptual model (Abdi, 2010; Wold, 2001). The PLS-SEM approach yields better results in analyzing an exploratory study like this (Hair et al., 2019). Besides, this technique does not require any sample restrictions in the survey (Willaby et al., 2015). This technique applies to data that does not have a normal distribution. The CB-SEM technique cannot analyze this kind of data (Ringle et al., 2012). The prospective respondents i.e., Indian e-commerce customers were informed that the aim of this study is purely academic.

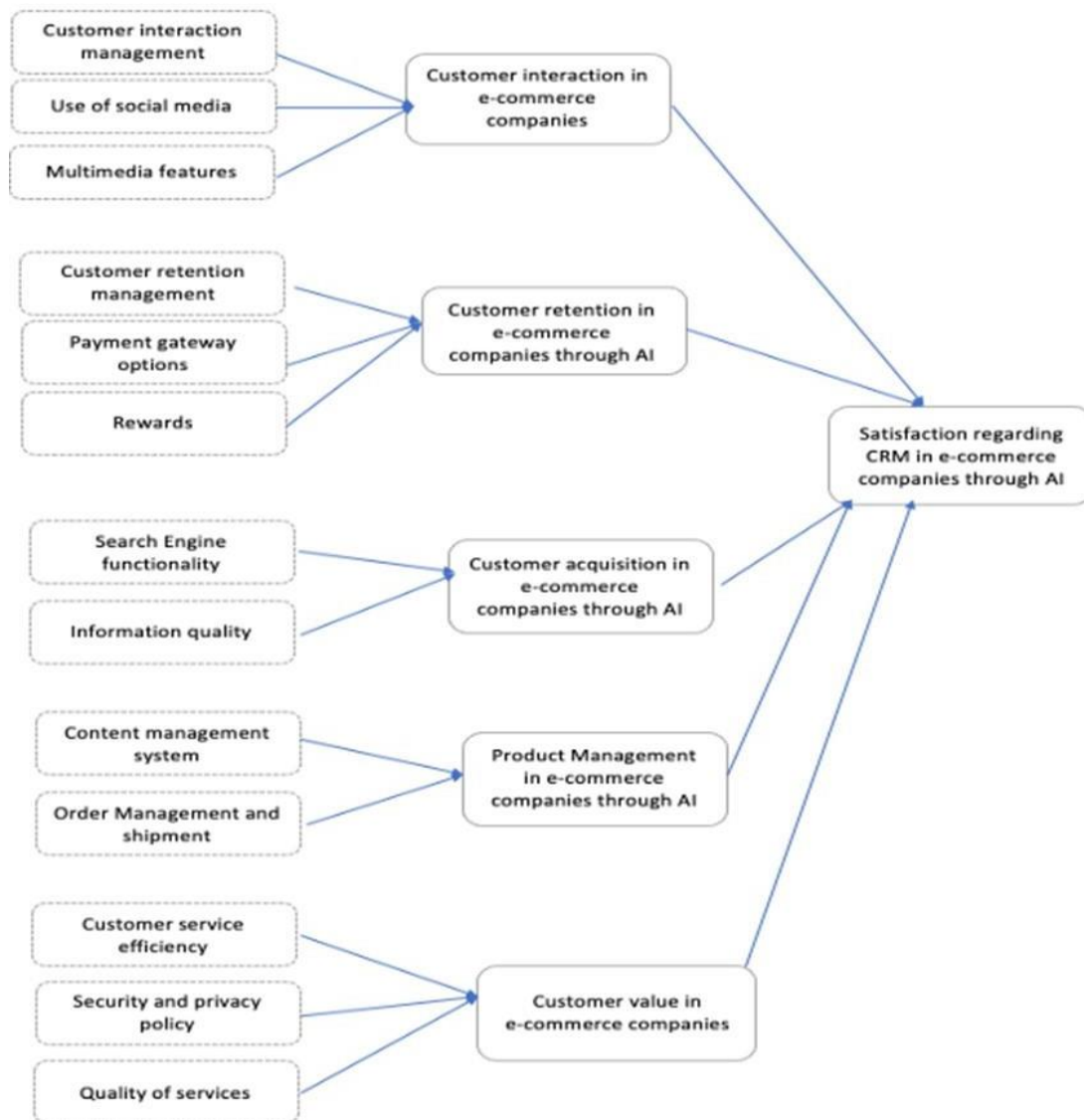
Secondary Data

Secondary data was gathered from various resources such as reports published by research firms such as Statista and McKinsey, which provided industry trends and case studies on the implementation of AI in CRM systems within the Indian e-commerce context. Relevant academic papers on Customer satisfaction and AI adoption were also reviewed to build theoretical framework.

Conceptual Model

Figure 1 represents the conceptual model of this study. This model explores the integration of Artificial Intelligence into Customer Relationship Management systems within the framework of organizational agility. It focuses on the intersection of three key business concepts: CRM, e-commerce models and AI. The paper investigates the value and impact of these concepts on knowledge and practice in the Indian context.

Figure 1: Conceptual Framework for Analyzing AI-Powered CRM in e-Commerce among Indian Customers.



Source: Author own source

Sampling

In this study, Stratified Random Sampling was chosen to ensure a balanced representation of key demographic groups within the Indian e-commerce market. The strata were defined based on age, gender geographic location and income levels allowing for a more nuanced understanding of customer satisfaction across different segments. Stratified Random Sampling was used to enhance demographic diversity, capturing varied perspectives across different age groups, income levels and locations which is crucial given the diversity of the Indian consumer base (Etikan and Bala, 2017).

Sample Distribution and Demographics

The 662 respondents were distributed across different age groups, genders and income levels. The sample included a variety of people from different geographic regions within India, ensuring the findings were reflective of both metro cities and smaller urban centres. Gender balance was maintained and income levels were also considered to capture varying levels of access to e-commerce platforms and AI-powered CRM systems.

Results

Descriptive Statistics

A summary of the respondents' demographic, socioeconomic and preference-related decisions is provided. The sample consisted of 662 individuals with 366 (55.28%) identifying as men and 296 (44.71%) as female. Most participants were private employees with 216 (32.6%) falling in the 31-40 age range and 176 (26.5%) in the 20-30 age group. The majority of employees reported monthly wages over Rs. 40,000, followed by 20,001-30,000 (238; 35.9%; and 221; 33.3%, respectively). Respondents widely use the internet at home (316; 47.7%) and in work places (242; 36.5%). Respondents primarily use the internet for emailing, education and games (427; 64.5%), with shopping being the next most common activity (155; 24.7%). Mobile data is the most common way people access the internet, accounting for 64.5 %. The majority of online purchases are made sporadically with 31.4% occurring once a month and 21.3% happening less frequently. Respondents use several websites and mobile applications such as Amazon, Flipcart, Snapdeal, Paytm and Shop clues to buy a wide range of things online, including books, cosmetics, fashion, home furniture and electronics (396; 57.7%).

Validity of the Measurement Model

Fornell and Larcker (1981) used factor loadings, Composite Reliability (CR), Average Variance Explained (AVE), and Reliability (Cronbach's alpha) to check for construct convergence. CR values of 0.7 or higher, all standardized factor loadings of 0.5 or higher and AVE values of 0.5 or higher indicate convergent validity (Cheung et al., 2023; Henseler, 2015). Table 1 reveals that the higher order construct measurement model meets CR, standardized loading, AE and Cronbach's alpha requirements. This study validates the higher order concept for measurement model evaluation. Each component was assessed for reliability and convergent validity. This study's LOC latent scores are used to assess HOC discriminant validity according to Sarstedt et al., (2019). The HOCs (CI, CR, CA, PM and CV) shows reliability and validity. Summarizing the results, all other constructs had reliability > 60 and convergent validity > 50 (Table 1).

Table 1: Higher Order Construct Validity and Reliability

Construct	AVE	CR	Cronbach's Alpha
Satisfaction	.620	.737	.912
CI	.647	.713	.710
CR	.537	.696	.790
CA	.701	.624	.721
PM	.640	.689	.703
CV	.579	.701	.752

Source: Author's Analysis

Discriminant Validity

The discriminant validity assessment ensures that a reflective construct has the strongest connections with its own indicators in the PLS path model (Hair et al. 2019). We check the CI, CR, PM, CA and CV's discriminant validity with the endogenous variable i.e., satisfaction reading CRM. Another thing we look at is their reliability and validity. According to Franke and Sarstedt (2019); Gold, Malhotra and Segars (2001), Fornell and Larcker's (1981) criterion shows that the construct's square root of AVE is greater than its correlation with all other constructs and HTMT is less than 90. Table 2 shows that measuring model has good discriminant validity for the constructs under study. In particular, all values are below 0.85, indicating construct discriminant validity. Each construct's correlations with indicators of other constructs are lower than those of the same construct, showing that they are separate and not significantly overlapping.

Table 2: Higher Order Construct Discriminant Validity: Heterotrait-Monotrait ratio (HTMT)

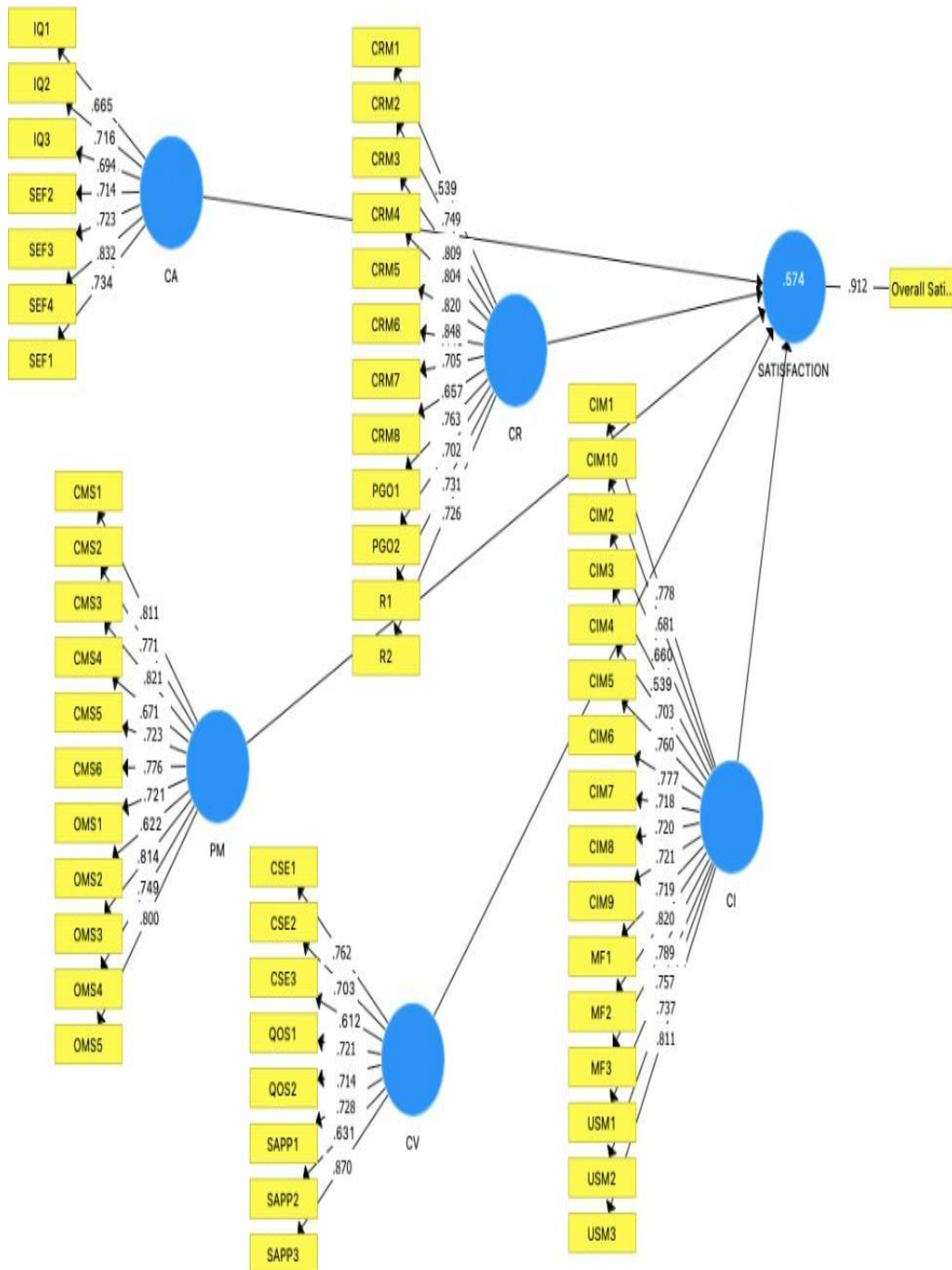
Construct	Satisfaction	CI	CR	CA	PM	CV
Satisfaction regarding CRM (Satisfaction)						
Customer Interaction (CI)	.678					
Customer Retention (CR)	.234	.533				
Customer Acquisition(CA)	.542	.674	.776			
Product Management(PM)	.573	.501	.654	.523		
Customer Value (CV)	.476	.478	.541	.435	.742	

Source: Author's Analysis

Assessment of Structural Model

The evaluation in PLS-SEM emphasizes the importance of path coefficients' significance and relevance, as well as the model's explanatory and predictive capabilities. The structural model mirrors the paths proposed in the research framework. The proposed paths in the research framework are evident in the structural model. Pathways' significance, along with R2 and Q2, is utilized for assessment. According to Figure 2, the model's R2 value is 0.574, which means that the independent variables in the model can account for about 57.4% of the variability in the dependent variable. Put simply, the independent variables (CI, CR, CA, PM and CV) explain 57.4% of the variation in dependent variable (Satisfaction). The R2 value for the dependent variable, which should be 0.1 or higher, serves as a measure of how strong each Structural path is in the model (Falk and Miller, 2014). Table 3 and Figure 2 display an R2 value of 0.574, considered substantial as it exceeds 0.1.

Figure 2: Measurement model with R2 value



Source: Author's Analysis

Therefore, predictive capability is established. Q2 further validates the predictive significance of endogenous elements. A Q2 value above zero suggests that the model is predictive (Q2 = 0.106). Furthermore, the model fit was assessed using SRMR. The SRMR score of 0.086 falls below the critical threshold of 0.10, suggesting a satisfactory model fit (Hair et al. 2019).

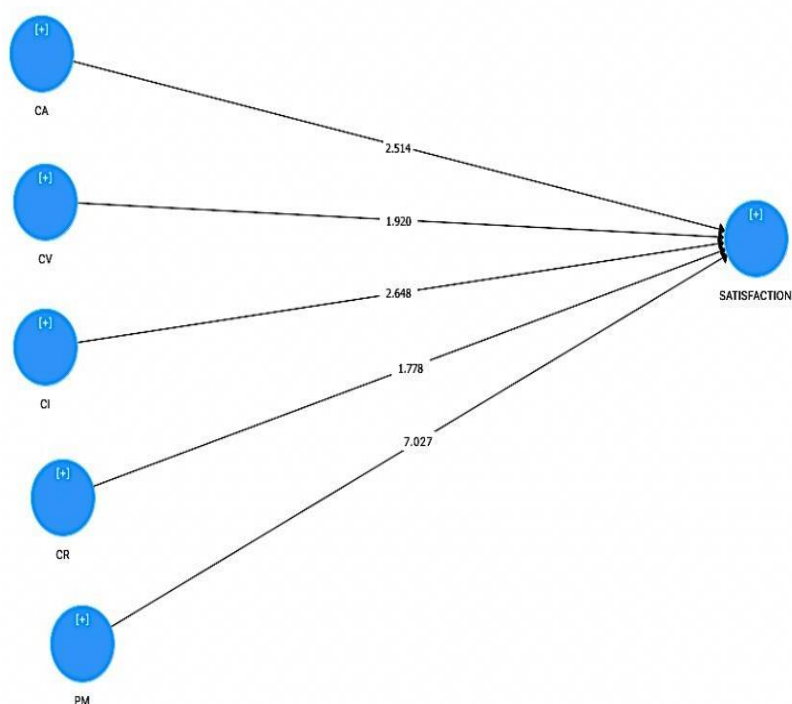
Table 2: Hypothesis Testing (Path coefficient)

Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (ST DEV)	T statistics (O/STDEV)	P Values	Result
H1 CA ->	.067	.087	.078	2.514	.001	Supported
H2 CV -> S	.553	.156	.056	1.920	.002	Supported
H3 CI -> S	.987	.945	.059	2.648	.000	Supported
H4 CR -> S	.679	.768	.065	1.778	.001	Supported
H5 PM -> S	.084	.784	.054	7.027	.000	Supported
Goodness of the model	Estimate	Threshold				
R ²	0.574	More than 0.1				Acceptable
Q ²	0.106	Greater than 0				Acceptable
SRMR	0.086	Less than 0.1				Acceptable

Source: Author's Analysis

CA, CV, CI, CR and PM significantly impact satisfaction (CA – S: $\beta = 0.067$, $t = 2.514$, $p < 0.001$), CV – S: $\beta = -.553$, $t = 1.920$, $p < 0.002$), (CI – S: $\beta = .987$, $t = 2.648$, $p < 0.001$), (CR – S: $\beta = .679$, $t = 1.778$, $p < 0.001$) and (PM – S: $\beta = .084$, $t = 7.027$, $p < 0.000$). Consequently, H1, H2, H3, H4 and H5 were supported. Results showed little impact on satisfaction.

Figure 3: Structural Model with T – Statistics



Source: Author's Analysis

The statistically substantial positive connection suggests that PM, CI and CA approaches could influence satisfaction a bit stronger. To increase satisfaction outcomes, customers may benefit from improving CV and CR processes. These findings might help decision making and resource allocation by highlighting the importance of critical factors in promoting AI outcomes and identifying areas where efforts might not be effective.

Discussion

In the Indian e-commerce sector, amidst intense competition and evolving customer demands, embracing a customer focused strategy is crucial for achieving success. E-commerce companies can foster trust and loyalty by focusing on customer interaction and offering personalized support and assistance at every stage of the customer journey.

To effectively engage with customers, businesses must initiate interactions, reply promptly to inquiries, and tailor communication to individual preferences (Davis et al., 2021). Customized interactions can improve customer satisfaction as clients recognize value and empathy from online businesses that utilize CRM efficiently. Responding promptly and effectively to customer inquiries in the Indian e-commerce sector can significantly impact satisfaction levels, given that customers often require assistance and guidance while shopping (Goutham et al., 2021; Davis et al., 2021). Utilizing different customer service channels, such as live chat support, email assistance and social media engagement has been proven to enhance customer satisfaction for e-commerce businesses (Kumar and Ayodeji, 2021).

Multiple strategies like loyalty programmes, personalized discounts and exclusive offers are employed to promote repeat purchases and foster long lasting customer relationships (Goutham et al., 2021). The study findings align with previous research indicating a significant correlation between customer loyalty and positive outcomes like satisfaction, commitment, profitability and sustained growth (AI-Adwan et al., 2020). Implementing retention strategies in the Indian e-commerce industry is essential for preserving customer loyalty in the face of fierce competition and high turnover rates (Kumar et al., 2020). To enhance customer satisfaction and encourage repeat purchases, e-commerce businesses can offer personalized incentives and rewards tailored to match customer behaviour and preferences (Varsha et al., 2021).

Strategies for customer acquisition include drawing in new customers to the e-commerce platform via focused marketing efforts, referral initiatives and strategic collaborations (Pasaribu et al., 2022). Research suggests that acquiring new customers can be more expensive than retaining existing ones. Implementing successful acquisition strategies can lead to an increase in market share revenue. In 2018, a study was conducted by Jaiswal and colleagues. Efficient customer acquisition strategies are crucial in the Indian e-commerce industry to expand the customer base and adjust to changing consumer preferences, ultimately enhancing satisfaction for new users (Goutham et al., 2021). By utilizing data analytics and market segmentation, e-commerce companies have the potential to enhance customer satisfaction through personalized experiences and targeted promotions for new users (Kumar and Ayodeji, 2021).

To enhance the shopping experience, it is essential to offer top-notch products, detailed product descriptions and easy to use navigation (Goutham et al., 2021). The study indicates that product related factors like quality, availability and presentation significantly influence customer satisfaction and purchasing decisions (AI-Adwan et al., 2020). Indian e-commerce platforms should adopt efficient product management strategies to tackle issues regarding product authenticity and quality, thereby building trust and assurance among customers (Kumar et al., 2020). By providing comprehensive product details, customer feedback and suggestions, e-commerce businesses can enhance customer satisfaction and loyalty (Kaul, 2017).

AI systems have made a notable impact on different sectors, such as gaming and education. In the gaming industry, AI technologies have facilitated the development of gamification strategies that utilize game elements to improve customer engagement and communication (Wagan et al., 2023). This method has proven effective in enhancing customer loyalty and productivity across various industries (Nam, 2021). AI has been applied in the education sector to enhance learning outcomes and efficiency. Intelligent tutoring systems offer personalized feedback and learning pathways, while AI agents improve student interaction and foster a sense of responsibility (Shankar, 2022). AI facilitates personalized learning through autonomous scoring, Chabot and the gamification of learning. In addition, AI can support simulations, serious games and the analysis of learning data (Ubah et al., 2022). AI-assisted systems could potentially transform the gaming and education sectors by improving engagement, customization and educational results.

In addition, the emergence of AI-assisted systems has significantly impacted sectors like gaming and education, fundamentally altering the execution of tasks and the delivery of experiences. The research study aimed to offer insight into the advantages and obstacles that AI presents in different industries based on the results obtained.

Artificial Intelligence has enhanced the gaming experience through the implementation of dynamic environments and customized interactions, leading to enhanced gameplay. It is crucial to address ethical challenges and biases to ensure inclusive experiences. Artificial Intelligence could improve personalized learning and boost educational outcomes. It is crucial to consider privacy and equality issues. Artificial Intelligence demonstrates creative potential but requires a thorough analysis of its ethical and societal implications. Collaboration across disciplines is crucial for maximizing benefits and minimizing risks.

Conclusion and Recommendations

Overall, the hypotheses put forth in this study are corroborated by the existing literature and empirical data, suggesting that effective Customer Interaction, Customer Retention, Customer Acquisition, Product Management and Customer value have a positive impact on customer satisfaction in Indian e-commerce websites. By adopting strong CRM practices and focusing on customer centric initiatives, e-commerce enterprises may improve satisfaction levels, cultivate loyalty, and stand out in a competitive market. This comprehensive analysis offers useful perspectives and practical suggestions for e-commerce organizations aiming to enhance CRM implementation and boost customer happiness in India. For this using the advanced AI and machine learning models to offer more accurate recommendations, personalized discounts and proactive customer support. It is recommended to use predictive analytics to anticipate customer needs and initiate tailored interactions before customers even ask. E-commerce platforms should leverage AI to segment customers based on behaviour and preferences offering personalized loyalty rewards. These rewards could include discounts, exclusive offers and special deals tailored to each customer's specific purchase patterns and preferences. E-commerce companies should foster collaborations with AI developers and researchers to keep up with emerging technologies. Investing in AI research and development can help explore innovative solutions that can enhance customer engagement and operational efficiency.

Limitations and Future Direction

Customers in different locations may face different AI adoption obstacles and opportunities. Age and gender can be used as moderators to study new dimensions and insights on AI-driven CRM adoption and outcomes. While AI-enabled CRM implementation holds great promise for Indian e-commerce companies, addressing limitations related to data privacy, digital divide, bias and regulatory challenges is crucial. By embracing ethical AI frameworks and focusing on personalized customer experiences, multi-channel integration and continuous learning, e-commerce companies can unlock the full potential of AI-driven CRM to drive customer satisfaction and business growth in India's dynamic e-commerce landscape. However, research on employee acceptance of AI-integrated CRM systems in India is limited, Future studies can explore the use behaviour of employees and the impact of AI-integrated CRM systems on organizational agility in India. Further research is needed to investigate the effective integration of human and AI capabilities to improve organizational agility. Exploring the significance of human judgement, intuition, and creativity in enhancing AI-driven insights and decision making. Exploring interdisciplinary research methods can offer a more profound understanding of the intricate relationships among technology, organizations and customers leading to a comprehensive grasp of organizational agility. Finally, it is essential to conduct longitudinal studies to evaluate the extended effects of AI-integrated CRM systems on organizational agility. It is essential to monitor organizational performance metrics consistently to detect trends, patterns and factors that support ongoing agility and competitive edge.

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An Empirical Analysis of Growth Opportunities for Spice Export Firms in Tamil Nadu

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Abstract

Spices are an essential commodity in international trade, playing a significant role in the global economy. India has consistently maintained its leadership in this domain, commanding a substantial 20% share of the global spice export market. Within this context, the present study focuses on analyzing the growth prospects of the spice export industry in Tamil Nadu, a region known for its rich agricultural heritage and significant contributions to the spice trade. The study adopts a quantitative research approach, drawing insights from data collected through structured questionnaires administered to 318 spice exporters in Tamil Nadu. A 13-item questionnaire was designed, employing a five-point Likert scale to capture respondents' perceptions, with response options ranging from 1 ('strongly disagree') to 5 ('strongly agree'). The research model underwent rigorous evaluation to ensure its validity and reliability.

Exploratory Factor Analysis (EFA) was conducted as an initial step, resulting in the removal of two items to refine the model. This was followed by Confirmatory Factor Analysis (CFA) performed using SPSS Amos 23, which provided a robust methodological framework for the study. Results from the second-order CFA revealed that the success of spice exporters is predominantly driven by the adoption of global expansion strategies and the enhancement of operational competitiveness, highlighting critical factors for industry growth. Results from the second-order CFA reveal that the success of spice exporters is primarily driven by the implementation of global expansion strategies and the enhancement of operational competitiveness. Additionally, the findings highlight the critical importance of adopting a proactive and adaptive approach to international market growth. This includes delivering post-sale value, aligning with evolving market dynamics, and addressing the changing preferences of global customers. Based on these insights, the study provides valuable implications for both exporters and policymakers. It presents strategies to enhance the potential of the spice export industry and secure its long-term sustainability in the global market. These findings emphasize the need for strategic planning and adaptability to maintain competitiveness and capitalize on emerging opportunities in the international spice trade.

Keywords: Competitiveness, Global Strategies, International Market, Market Adaptability, Spice Exports.

Introduction

Spices have historically played a crucial role in trade, influencing economic, social, and political developments worldwide (Bhardwaj et al., 2011; Thomas, 2019). India remains the global leader in the spice trade, being the largest producer, consumer, and exporter of spices (Anusha et al., 2020). The country is renowned for its spices not only due to its vast production volume and variety but also for its distinctive aroma, taste, and texture. According to the International Organization for Standardization (ISO), India's diverse agro-climatic zones allow it to produce 75 of the 109 recognized spice varieties globally.

India has maintained its leading position, currently holding a 20% share of the global spice export market (Yes Bank & Spices Board, 2023). The trade is largely driven by chilli and pepper, which together account for over one third of the global spices export value (Spices Board of India, 2023). However, recently, India's spice export industry has encountered challenges concerning quality standards; this has resulted in bans on Indian spices in international markets (Dalmia, 2024). For instance, the U.S. Food and Drug Administration Import Refusal Report last year indicated that one-third of spices and herbs exported from India were rejected due to salmonella contamination ("After Pesticide, MDH Now Faces Heat for Salmonella Contamination," 2024). This controversy, involving prominent Indian spice brands such as MDH and Everest, has further disrupted India's global spice market (Dalmia, 2024).

Given these challenges, examining both the issues and opportunities with in Indian spice exports is essential for understanding India's position in the global spice market. Bhatt & Valasan (2016) found that unfair practices, such as adulteration, along with volatile pricing, could stifle market growth. Building on this, Anbuchelvi (2019) explored the challenges and potential in exporting value-added spices like oils and oleoresins, emphasizing the need for strategic interventions. Additionally, Nair (1987) analyzed cardamom marketing, identifying both obstacles and future opportunities for Indian spices. Thomas et al. (2024) noted that research on spice production, marketing, and trade systems could guide policy development to support the spice economy. However, a comprehensive review of existing literature reveals that prior studies have largely neglected the specific prospects for spice exports. Therefore, this research aims to address this gap by identifying key business prospects for Indian spice export firms to strengthen India's presence in the international spice market.

The first section of the study offers an overview of the research, focusing on the potential for spices exports from India. The second section reviews previous academic studies to understand foreign market opportunities, market expansion, quality management, and future prospects for Indian spices. The third section outlines the data collection process and explains its relevance to the study, followed by a description of the research methodology used to assess empirical evidence. In the fourth section, we present empirical findings supported by critical analysis and discussion. The subsequent section interprets these results, offering valuable insights for both researchers and industry professionals.

Literature Review

The literature synthesis on the prospect of spice exports in international markets encompasses academic research to explore the potential of India's spices exports globally. Bhattacharya's (2002) study on commodity export prospects revealed that successful trade depends on both opportunities and challenges in the international market. The study further highlighted that countries with a substantial share of global consumption and a significant portion of world imports represent valuable opportunities for expanding exports.

Notable research by Manova & Zhang (2012) emphasizes that expanding agricultural trade between countries requires diversifying traded goods and optimizing trade potential. Furthermore, it highlighted that exporting countries must enhance quality control measures for their agricultural products to remain competitive. Tian (2023) highlighted that the overall prospects for agricultural trade are promising, with individual countries having the potential to expand and become more integrated into global markets. Similarly, Kondratieva et al. (2022) identified key strategic areas necessary for developing the agricultural sector and increasing export volumes. Their study also recommends substantial policy amendments to adapt to new global conditions and accelerate growth in the spices trade. Besides Zhang et al. (2023)'s identified trade prospects for Latin American countries exporting agricultural products to China and suggested expanding trade categories and improving quality control to enhance trade potential.

Cuyvers (2004) identifies Thailand's export opportunities, furthermore highlighting that individual countries, particularly in the Asia-Pacific region, present more opportunities. These opportunities are listed and categorized based on criteria such as import market characteristics and Thailand's market share in the various markets. In addition, Peu (2019) suggests proactive government actions to improve business infrastructure through capital investments. Furthermore, effective policy-making could enable industries to outperform competing countries in global markets.

While numerous studies have examined the export prospects and challenges of various products, research specifically focused on spices exports, where India is a global leader, remains limited. Moreover, most existing research relies heavily on quantitative data, leaving a significant empirical gap.

Moreover, The sample area is Tamil Nadu, a major spice-exporting state in India. According to the Spices Board of India, Tamil Nadu spice exports were valued at USD 200.96 million in 2019, increasing to USD 222.18 million in 2023. The state is known for exporting a diverse range of spices, including black pepper, cardamom, turmeric, clove, chili, curry leaves, and mustard seeds.

Hence, this study addresses that gap by building on previous research and empirically identifying the factors that influence the prospects of spices exports in Tamil Nadu.

Research Question

What are the key business prospects of spice export firms in Tamil Nadu?

Objective Of The Study

To identify the key business prospects of spice export firms in Tamil Nadu.

Data and Research Methodology

Existing literature underscores that the factors shaping the prospects of spice exports are not universally fixed; they fluctuate across countries, sectors, and over time. Recognizing this variability, the present study is dedicated to identifying and examining the specific opportunities that define the export landscape for Indian spices.

Questionnaire Development

To measure the prospects for spices exports, a 13-item questionnaire was developed based on a review of existing literature. Ultimately, 11 items demonstrating good face and content validity (Hinkin et al., 1997) were retained. The questionnaire was divided into two parts: the first part consisted of 11 statements measuring the prospects for spices exporters on a five-point Likert scale, with responses ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'. All 11 statements indicating the prospects for spices exports were coded positively. The second part of the questionnaire collected the demographic profiles of the respondents.

Data Collection And Sample Profile

This study utilizes primary data collected from spice exporters through an 11-item structured questionnaire. The exporter data was drawn from the Spices Board's database. The total population comprises 414 spice-exporting firms in Tamil Nadu. (Ministry of Commerce and Industry, Government of India), which provides comprehensive information on spice exports. Invitations 414 spice exporter were sent via email to the managers and executives of these firms. The questionnaire was distributed to the entire population, and factor analysis was performed on the collected responses. A total of 318 responses were received, of which 300 were deemed valid for the factor analysis.

The demographic profile of the respondents indicates that 77.6% of exporters have fewer than 10 years of experience in international trade. Notably, 38.8% of respondents represent private enterprises, underscoring the substantial role of the private sector in spice export market. Additionally, the majority of respondents (65.3%) are merchant exporters. Among these, 80.8% are categorized as small exporters, with annual export volumes below USD 3 million (INR 20 crore). Concerning customs duties on spices, 61.5% of respondents consider them moderate. In terms of capital structure, 34% of respondents rely primarily on self-financing, while 42.3% utilize cash-in-advance payment arrangements, reflecting a preference for pre-paid transactions in international dealings.

Data Analysis And Results

Exploratory Factor Analysis (EFA)

To analyze the data collected from the 11-item questionnaire, the study employed exploratory factor Analysis (EFA) using principal component analysis and varimax rotation. The Kaiser-Meyer-Olkin (KMO) measure of 0.826 confirmed the adequacy of the sample for factor analysis. Bartlett's test of sphericity indicated that the correlation matrix was significant ($p < 0.000$). Additionally, the total variance explained by these two dimensions was 69.83%, suggesting that the questionnaire captured a substantial portion of the variance. The EFA resulted in the identification of two dimensions.

Cronbach's alpha, a measure of internal consistency, was used to assess the reliability of the dimensions. A value above 0.6 is considered moderately acceptable ensure the validity and reliability of the instrument, with individual construct values ranging from 0.612 to 0.854. (O'Hair et al., 1998). Table 1 presents the EFA results.

Table 1: Exploratory Factor Analysis

Factor	Item Code	Item Content	Factor Loadings	Cronbach's Alpha
Global Expansion Strategy	GES2	Prospects for continuous expansion in foreign markets.	.890	.916
	GES1	Opportunities to explore new foreign markets.	.869	
	GES3	Expected strong foreign demand for spices products.	.718	

Factor	Item Code	Item Content	Factor Loadings	Cronbach's Alpha
	GES5	Opportunities to provide after-sales services to overseas buyers.	.667	
	GES6	Adaptability to changing customer needs and market conditions.	.648	
	GES4	Competitive advantages over other spices exporters.	.599	
Operational Competitiveness	OC4	well- positioned to ensure on-time delivery of shipments.	.801	.839
	OC1	Opportunities to maintain high-quality management standards.	.710	
	OC2	Strong local reputation and global contacts.	.705	
	OC3	Prospects to offer competitive prices for spices exports.	.668	
	OC5	Opportunities to increase R&D efforts in product innovation.	.631	

Source: Computed by the authors.

Confirmatory Factor Analysis (CFA)

To validate the two constructs obtained from EFA, CFA was performed using AMOS 23.0. To ensure the model fit, modifications were made based on the standardized residual covariances and error covariances. The CFA model runs 300 responses. It was observed that the standardized estimates of the second-order construct, namely "business prospect", was created by combining these two first-order constructs.

Table 2: Model fit Measures

Measure	Estimate	Threshold	Interpretation
CMIN	3.306	--	--
DF	3	--	--
CMIN/DF	1.102	Between 1 and 3	Excellent
CFI	1.000	>0.95	Excellent
SRMR	0.016	<0.08	Excellent
RMSEA	0.019	<0.06	Excellent
PClose	0.626	>0.05	Excellent

Source: Computed by the authors

Table 2 shows that the initial model did not achieve the fitness, so we deleted items with factor loading for less than 0.4 (Deleted items = GES1, GES3, GES4, OC10, OC6, OC11) and created covariance of error terms based on modification. The final model that emerged was a first-order CFA. Factor loading for each item representing different constructs ranged from 0.83 to 0.91. The model fit was ensured based on the values of the following two indices: CMIN/DF(3.306), CFI(1.000), SRMR(0.016), RMSEA(0.019), and P Close (0.626), which showed an excellent fit (Gaskin & Lim, 2016).

The model displayed strong validity, with no significant concerns. Convergent validity was confirmed as the average variance extracted (AVE) exceeded 0.83 across all factors. Discriminant validity was ensured by comparing the square root of the AVE with the correlations among the respective variables, indicating clear differentiation between constructs. Lastly, composite reliability demonstrated the internal consistency of the measurement model, affirming its reliability and robustness.

Figure1: Business Prospects Of Spices Export Firms

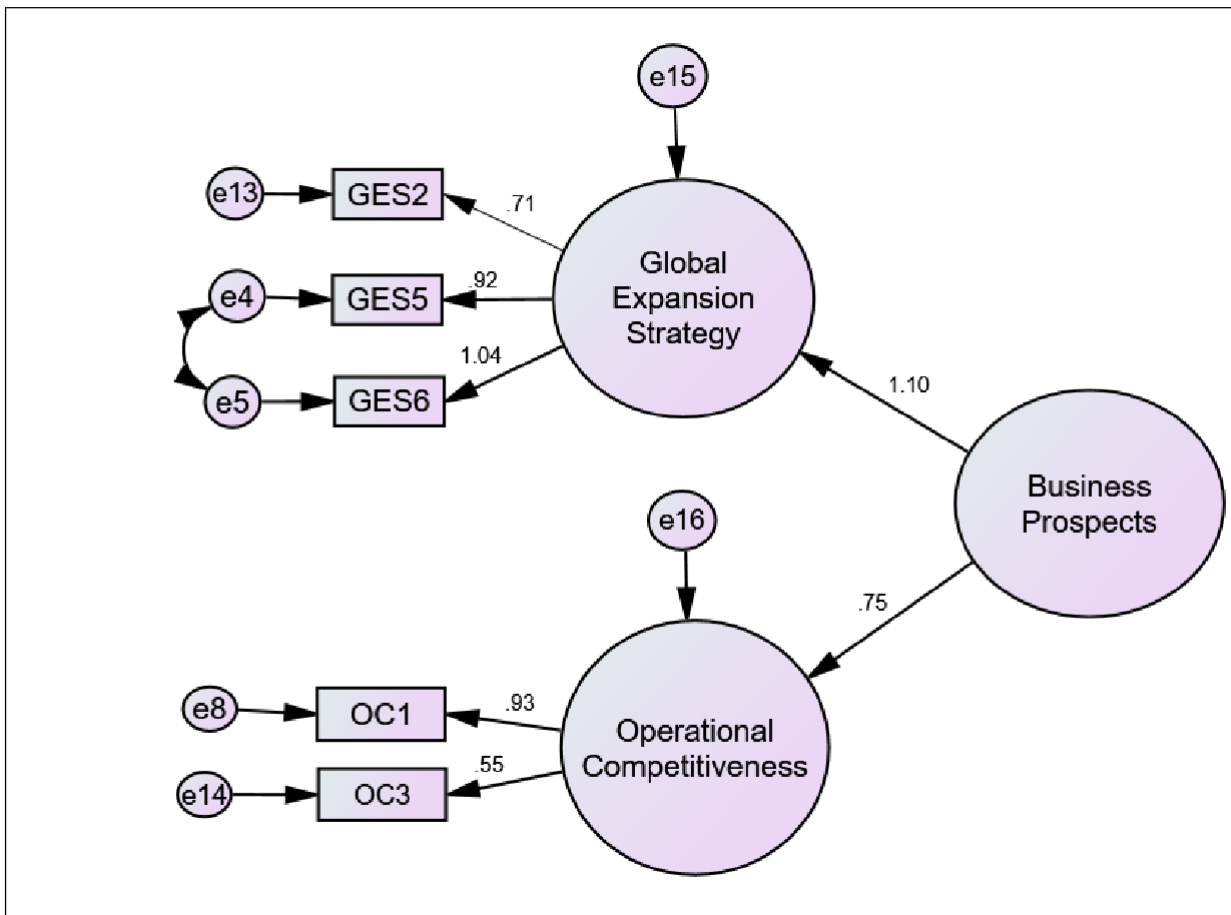


Figure1: Second order CFA

As shown in Figure 1, the second -order CFA results revealed that the business prospects for spices exports can be associated with two main components: the first-order construct, which is assessed through 'global expansion strategy' and 'operational competitiveness,' both contributing to the overall spices export business prospect in Tamil Nadu.

Discussion

This analysis uncovers essential insights derived from constructs identified through the second-order CFA, each supported by relevant indicators. These findings illuminate the strategies shaping growth and competitiveness in the spice export business.

The Global Expansion Strategy in the context of the spice export business combines foreign market expansion, after-sales service for overseas buyers, and an understanding of customer needs. This strategy highlights spice export firms' ongoing efforts to grow their presence in new international markets. It also involves aligning strategy content with individual marketing mix variables to effectively meet international customer needs, reflecting a long-term commitment to global growth rather than a one-time initiative. The focus is on building sustainable relationships and steadily expanding the international footprint of spice export firms. This strategy emphasizes the importance of providing support to customers even after the sale, as strong after-sales service fosters trust and enhances customer satisfaction critical factors in international trade.

Additionally, this construct addresses spices export firms adaptability to global market trends and customer preferences. this study finding aligns with the Szymanski et al.(1993)finding that identified two key strategies for expanding into Western markets. Highlighting the first involves standardizing resource allocation patterns across marketing mix variables. Similarly, the study's findings align with those of Lubis & Muniapan(2024),who emphasize the importance of conducting competitive analysis. Further such analysis helps companies differentiate their products, build competitive advantages, and improve market positioning, ultimately leading to a larger share of the international market.

Operational competitiveness in the context of a spices export business combines quality management and cost leadership to create a strategy where the spices export can effectively compete on both quality and price. By ensuring stringent quality control measures throughout the production and supply chain, exporters can meet global standards and cater to the demands of diverse markets. Simultaneously, optimizing operational efficiency through cost-effective sourcing, production techniques, and logistics enables the business to keep prices competitive. This dual focus allows the spices exporter to deliver high-quality products while maintaining cost leadership, enhancing its ability to capture market share, penetrate new markets, and sustain profitability in an increasingly competitive global spices industry. This finding aligns with Hordofa & Tolossa(2020), who observed that Ethiopia was unable to enhance its production capacity and improve quality, which prevented it from becoming a competitive player in the global spices market. In the context of spices exports, excelling in both quality and price allows a company to attract international buyers seeking reliable suppliers that offer consistent product quality at competitive prices.

However, the study by Manova & Zhang (2012) contradicts our findings regarding international trade. It suggests that successful exporters use higher-quality inputs to produce superior goods and adjust product quality according to different markets. Firms often utilize inputs of varying quality levels depending on the destination market.

This study revealed that global expansion strategies and operational competitiveness are key business prospects for the spices export firm in Tamil Nadu. A special emphasis on export quality is necessary, as Indian spices have faced several challenges related to quality issues. These challenges have led some countries to prefer importing branded spices products from other sources, negatively affecting spices exports in Tamil Nadu. However, efforts are being made to resolve these issues and reclaim India's position as the leading player in the global spices market.

Limitation and Scope for Future Studies

The first limitation of the study was that data collection fieldwork had to be extended for a longer duration. The second and major limitation of the prospect of spices exporting firms is the absence of in-depth interviews with respondents. Also, the study can be further extended to other regions of India such as Kerala, Karnataka, and Andhra Pradesh, Maharashtra and Gujarat.

Conclusion

Through the second-order CFA, the study identified key business prospects for spices exports in the international market. The findings revealed that the prospects for spices exporters are driven by global expansion strategies and operational competitiveness.

A dynamic approach to international business growth, which includes providing providing post-sale value and remaining adaptable to evolving market conditions and customer demands, is essential for success. These factors are likely to shape the future of spices export industry. Based on the evidence from our study, we offer implications for both spices exporters and policymakers to enhance the potential of spices export industry.

Implications

The findings from this study on global expansion strategy and operational competitiveness have important implications for spices-exporting firms, policymakers, and the broader spices industry. Firms should strategically invest in market research, trade agreements, and logistics infrastructure to explore and penetrate new markets. By doing so, they can reduce their reliance on traditional markets, diversify revenue streams, and enhance resilience against global market fluctuations. Policymakers should support this expansion by negotiating favorable trade agreements, reducing export barriers, and offering financial incentives for market diversification. These efforts could strengthen India's position as a global leader in spices exports while simultaneously benefiting local economies by creating more jobs in spices-producing regions.

Additionally, firms must focus on improving both efficiency and product quality to remain competitive. Policymakers and industry leaders can contribute by supporting initiatives that provide access to advanced production technologies, quality certifications, and infrastructure designed to reduce costs and enhance operational performance.

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Assessing the Effectiveness of Parliamentary Oversight Committees in the Ethiopian Parliament

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Abstract

The purpose of this study was to assessing the effectiveness level of the Ethiopian parliamentary committees from 2016 to 2020, particularly focusing on oversight functions and examining their role in promoting transparency, accountability and good governance. The research investigates the committees' ability to hold the executive unit accountable, ensure transparency and prevent corruption. It also analyses the challenges faced by these committees, including limited resources, inadequate training and political interference. This study aims to measure the effectiveness of Ethiopian parliamentary committees using survey data from reliable sources like the House of People's Representatives (HPRs). It proposes that committee effectiveness should be measured by the extent to which committees perform their oversight functions consistent with their objectives.

The study employs a mixed-methods approach, combining qualitative and quantitative data collection and analysis method. Data were collected from 178 respondents who were selected by using random sampling techniques. A self-constructed structured questionnaire was used to gather research data from members of parliamentary committees. The descriptive analysis was employed to analyze the data. The research findings showed that the Ethiopian parliamentary committees had ten common oversight functions and the effectiveness level of the Ethiopian parliamentary committees on oversight functions was medium. It also provides insights into the strengths and weaknesses of parliamentary oversight committees in Ethiopia, highlighting areas for improvement and recommending strategies to enhance their effectiveness. The study concludes that the committees were not performing their oversight functions effectively expected of them as legislative agencies. The study recommends that the parliament should give strong attention in strengthening the committees and oversight functions of the parliament. The study also identifies the study's practical contributions and, finally, explains the study's limitations and makes suggestions for further research, such as conducting research on other functions of committees. Ultimately, this research was aimed to contribute in the strengthening of parliamentary oversight in Ethiopia, promoting a more accountable and transparent government that serves the interest of its citizens.

Keywords: Effectiveness, Oversight functions, Parliament, Oversight, Parliamentary Committees,

Introduction of the Study with a Backdrop

Parliament is an institution of democracy responsible for law-making, conducting oversight over the executive, and facilitating public participation, among others. (Madu, 2012). Given that its tasks are intrinsically numerous and complex, the Parliament is too unwieldy a body to effectively deliberate the topics that are brought before it (Sarangan et al., 2020). Due to this fact, the parliament is assisted by various parliamentary committees in carrying out its duties successfully since it lacks the time or expertise to thoroughly examine these issues on the floor of the house (Mattson and Strøm, 1995). A "parliamentary committee" is a group of parliamentarians appointed by the parliament to undertake certain specified tasks (Yamamoto, 2007). Parliamentary committees are now a large part of the business of the Parliament of the world's parliament (Monk, 2009). They are fundamental to the performance of a legislature.

Since Woodrow Wilson's time, the committee stage has played an essential role in the operation of parliaments that are found in different parts of the world. According to Delcamp (2018), the first legislative committees were formed in the United States in 1789 for the purpose of elaborating on the rules of procedure for each chamber. However, for many decades, comparative politics generally and legislative studies were focused on the two extreme cases of the US and the British parliaments (Longley and Davidson, 1998; Rahman, 2008). The use of parliamentary committees was most prominent in the United States Congress (Shaw, 2007). Much literature shows that American congressional committees are the most powerful and effective committees in the world (Sarangan et al., 2020).

The study of existing practices showed that the comparative research that has been carried out on political institutions is "rare and difficult" (Lees and Shaw, 1979, p. 346). The first substantial attempt to analyze parliamentary committees cross-nationally came in the late 1970s and was carried out by Lee and Shaw (Rahman, 2008). In the middle of the 1990s, a turning point was reached in the study of Western European parliaments in general and that of parliamentary committees in particular through the multidimensional substantive collection of studies, *Parliaments and Majority Rule in Western Europe*, edited by Doring (1995). In his review of parliamentary committees in European democracies (Strøm, 1998) adopted and extended his previous work, thereby surveying the structure, procedure, and power of parliamentary committees in 18 Western European democracies. He stressed that parliamentary committees are among the most important features of legislative organizations in contemporary democracies.

Studies show that, until recently, the parliamentary committee system found in legislatures in the developing world, including Africa, was usually not well developed (Shaw, 2007). According to Shaw, in many developing countries, few committees exist, and those that do meet infrequently. Initially, many democratic parliaments were modeled after the British parliament and reflected the Westminster system's tradition of weak parliamentary committees (Rahman, 2008). As a result, those parliaments that are based on other traditions often lack similar significant internal structures in the form of politically relevant committee systems (Longley and Davidson, 1998). However, it appears that the situation is changing, thereby keeping pace with the review of democracy in the developing world (Shaw, 2007). This history is true for African parliaments and parliamentary committees such as in South Africa, Kenya, Zambia, and Tanzania (Fisher, 1998; Burnell, 2002; Njoroge, 2010; Tafirenyika, 2012; Wong, 2013; Pelizzo and Kinyondo, 2014; Napier, 2018; NAK, 2022). These scholars conducted research exclusively focusing on parliamentary committees in Africa. Their studies revealed that the African parliamentary committees are not effective and well developed, and their effectiveness is affected by different factors, such as the lack of financial resources, inadequate legal frameworks, inadequate technical and administrative capacity, political interference, and lack of expertise

In Ethiopia, the creation, growth, and development of the parliamentary committee system are recent phenomena. The concept of parliamentary standing committees was incorporated in the 1995 FDRE Constitution. Like other nations' parliaments, the Ethiopia parliament is duty-bound to establish standing and ad hoc committees as it deems necessary to accomplish its functions. Since then, the Ethiopian parliament has established a parliamentary committee system composed of different types and numbers of committees. Currently, the house has about 10 standing committees (HPR, 1995). These committees have the duty to oversee government agencies to determine whether they have accomplished their tasks as specified in their annual budgets (HPR, 2016).

Literature has shown that the Ethiopian parliament has adopted the experiences of parliaments that are found in the United Kingdom, Germany, Canada, and India (Assefa, 2015; Andualem, 2018). All these followed a parliamentary system. Therefore, the Ethiopian parliamentary committee system is also believed to adopt a model of parliamentary committees from these four countries. Concerning research that focuses on the Ethiopian parliamentary committees, there is a lack of empirical studies. Therefore, we can infer that the Ethiopian parliamentary committee system is relatively less developed when it is compared with the above-mentioned African parliaments such as Kenya, South Africa, and Tanzania. However, whatever the stage of development of the Ethiopian parliamentary committee system, parliamentary oversight through oversight committees is also becoming an emerging practice in the Ethiopian parliament (HPR, 2016).

Statement of the Problem

According to Wang (2005), parliamentary effectiveness is the output of parliaments in terms of achieving their main responsibilities of representation, lawmaking, and oversight of the executive. Strong committees are a necessary condition for parliamentary significance (Fisher, 1998; Rommetvedt, 1998). They are critical institutions for the effective functioning of oversight functions (Griffith, 2005; Yamamoto, 2007; Rahman, 2008). Currently, the effective administration of parliamentary functions is handled by parliamentary committees, which is why they are characterized as the "engine room" (Faris, 2012, p. 13) of the parliament.

However, studies show that in many countries, parliaments and parliamentary committees are "ineffective" (Tseko and Hudson, 2009, p. V). In particular, parliaments and parliamentary committees in developing countries are less effective (NDI, 2000; Hudson and Wren, 2007). The 2005 UNECA report revealed that in many African countries, these duties [lawmaking and oversight] and obligations are rarely performed with efficiency and effectiveness (Pimentel). This report also discloses the most ineffective countries' parliaments, such as Swaziland, Kenya, and Ethiopia (Hudson and Wren, 2007, p. 18)).

However, there is limited literature when it comes to examining the effectiveness of parliamentary committees (Monk, 2009). The existing practices showed that there are few studies that have been conducted on this more demanding task of making the careful and detailed assessment necessary to determine their true value (Njoroge, 2010). This may be partially explained by the challenge of defining and evaluating the effectiveness of parliamentary committees (Ojha, 2012).

So far, there have been some research outputs that concentrate on the oversight function of the FDRE parliament (Awel 2011; Damtew, 2015; Aklilu et al., 2020). Despite some efforts to assess the effectiveness of parliament on oversight effectiveness at the parliament level, this was not the case for Ethiopian parliamentary oversight committees. As far as the researcher of this research has been able to explore related studies focusing on the effectiveness of the Ethiopian parliamentary committees in terms of performing their oversight functions, he has not been able to find an independent empirical study that shows the effectiveness of the Ethiopian parliamentary committees.

It is surprising that so little or non-empirical research has actually been conducted on the topic, especially from the perspective of oversight, despite an increased interest in using effective oversight committees. Therefore, the problem is that, while parliamentary committees are central in oversight function, the effectiveness level of the Ethiopian parliamentary committees are still left unexamined, have been little researched, or have not been examined.

Hence, it is important to raise the following two questions: - What are the oversight functions of the Ethiopian parliamentary oversight committees? What is the effectiveness level of the Ethiopian parliamentary committees on oversight functions? In order to answer these questions, this paper draws on a rigorous descriptive quantitative study to describe the effectiveness level of the committees.

Review of Related Theoretical Literature

Theories of Parliamentary Committees

The existing literature has shown that there are three legislative committee theories that are all related to the principal-agent theory. These are- distributive theory; informational theory; and patrician theory (Mattson and Strøm, 1995; Groseclose and King, 2001; Martorano, 2002; Wong, 2013; Mickler, 2017; Mokgari and Pwaka, 2018; Chowdhury, 2021). These theories characterize committees as having very different functions for legislatures and, more generally, as a type of legislative organization serving very different purposes (Prince and Overby, 2005).

The Distributive Theory

The distributive theory suggests that parliament's standing committees have unique jurisdiction over policy issues, allowing individual members to choose committees and ensuring independent oversight. This approach benefits constituents, increases re-election chances, and encourages negotiation with other lawmakers (Shepsle and Weingast, 1981; Martorano, 2002; Wang, 2013). The theory suggests that a strong committee is formed when committees are given explicit legal power, with committee preferences and autonomy. This allows individual parliament members to choose their committee and ensures a strong, independent role in policy-making and oversight. The distributive theory suggests that lawmakers take committee assignments seriously, as they provide material benefits to constituents, increase their chances of re-election, and negotiate deals with other lawmakers.

The Informational Theory

The informational theory suggests that legislators lack complete information to predict policy outcomes, leading to the establishment of specialized committees to gather necessary information. This system aids Parliament in providing expertise and scrutinizing governmental proposals (Krehbiel, 1992; Wong, 2013). The theory suggests that a highly specialized committee system, capable of transmitting information and reducing uncertainty, is crucial for efficient legislation and oversight processes. This theory suggests that such a system leads to increased efficiency and effectiveness in these processes (Mattson and Strøm, 1995). The informational theory was utilized to analyze the effectiveness of committees in Ethiopia, focusing on their adherence to inquiring information access, sharing, processing, and utilization within committees.

The Partisan Theory

The partisan theory (Cox and McCubbins, 2007) argues that distributive and informational theories overlook party politics in legislatures. The theory views committees as agents of majority party leadership, controlling appointments and committee decisions (Mickler, 2017). The committee system serves the majority party's needs, with strong committees acting as instruments of party leaders (Shaw, 2007). The strength and effectiveness of parliamentary committees are dependent on the party leader's leadership in the House.

The Ethiopian context of the theory aids in examining committee effectiveness factors, providing valuable insights into their functioning.

These three theories are all grounded in the principal-agent theory. In all of the theories, agents are committee members, and principals are constituencies, the parliament, and the party. According to Sarangan et al. (2020, p. 425), parliamentary committees are "meant to breathe life into the institution; they essentially act as agents by performing specific tasks that are delegated to them by the legislature". According to these theories, strengthening the committee system will be done to increase or achieve the ultimate goal of their principles. In addition to this, although the three theories differ in certain aspects, they all have one feature in common: they deal with institutional and legislative organization matters.

Functionalist Theory of Oversight

According to the functionalist theory of oversight, an oversight activity is one in which an actor that is, an agent or an institution known as the overseer supervises another actor, that is an agent or an institution known as the overseen (Kinyondo, R. Pelizzo and A. Umar, 2015). According to the functionalist theory of oversight, one should not ask whether oversight is effective in general, as simple metrics seem to assume. Rather, one should ask whether oversight is effective in performing a specific function. This theory was critical in determining the effectiveness of the Ethiopian parliamentary committees based on a functional approach. For example, the parliamentary committees have two basic functions: lawmaking and oversight functions (HPR, 2016). This study focuses on the oversight functions of the committees. However, within the oversight functions, the committees also have at least ten specific oversight functions which are taken as indicators. Therefore, this functionalist theory helped the researcher to evaluate the effectiveness of the Ethiopian parliamentary oversight committees based on their specific functions or indicators.

Functions of Parliamentary Committees

Parliamentary committees perform functions that Houses cannot, such as fact-checking, witness examination, evidence sifting, and drawing reasoned conclusions (Delcamp, 2018). They assist the parliament by overseeing executive accountability, facilitating public participation, and offering expertise and alternative career prospects to backbench MPs. Their main functions are similar to those of the House (Hazan, 2001; Chowdhury, 2021).

Rahman (2008) argues that parliamentary committees play a crucial role in making legislation decisions and overseeing administrative actions. While oversight and legislation can be conceptually separated, they are inseparably linked. Institutional modifications that strengthen legislative decision-making capacity reflect the legislature's ability to carry out oversight, with the best oversight often occurring during committees' legislative hearings.

Oversight Functions of the Committees

The oversight function of the legislature implies the surveillance of the executive agencies, especially by the legislature, and it is founded on the fact that the legislature enacts the laws that create administrative agencies and the governance architecture needed to manage the affairs of the state (Arowolo, 2023). When a legislature performs its oversight functions, it is supervising or overseeing the business of executive branch departments, ministries, or agencies in order to ensure prudent management of funds and frugality in governance (Egobueze and Anthony, 2020). According to Egobueze and Anthony, legislative oversight is effectively achieved through committees, and the committee system is an effective tool for accountability.

Scholars argue that democratic accountability between elections is exercised by both House representatives and committees (Mulgan, 2003; Mickler, 2017). Parliamentary committees are adaptable institutions that contribute to a systemic oversight framework. They track the work of individual government departments and ministries, conducting specific investigations into policy and administration aspects, making them the most important internal tool of a legislature (Griffith, 2005; Beetham, 2006).

Theory of Organizational Effectiveness

Understanding Effectiveness

Effectiveness is a broad concept that takes into account a collection of factors both inside and outside an organization. In general, effectiveness is the extent to which stated objectives are met—the policy achieves what it intends to achieve (Australian Government Commission, 2013). However, the concept of organizational effectiveness is not simple because there are many approaches to conceptualizing this term. Such approaches can be grouped into the following three main groups: Goal approach, functional approach and system approach (Cunningham, 2001).

The goal approach defines effectiveness as the degree of goal achievement, focusing on the desired state of affairs an organization aims to achieve, often referring to goals, objectives, purposes, and goals. The functional approach assesses an organization's effectiveness based on its social consensus of its activities, rather than its structure, rather than its overall societal benefit. The system resource approach emphasizes an organization's effectiveness in utilizing its environment to acquire scarce and valuable resources, rather than focusing on goal achievement.

The term "effectiveness" can vary across disciplines, such as management, where it refers to achieving the right thing (Patel, 2021), and parliamentary effectiveness, which refers to the output of parliaments in lawmaking, oversight, and representation (Wang, 2005).

The concept of effectiveness, used in organizational studies, can be applied to parliamentary committees. However, there is no single definition for committee effectiveness. It is defined differently by individuals and institutions, with the LCHC stating it measures its influence on government actions (Njoroge, 2010). Monk (2009) defining it as influencing the government and debate. The ANAO (2004) defines effectiveness as "the extent to which outputs and/or administered items make positive contributions to the specified outcome" (p. vii).

Rosenthal (1973) has defined effectiveness as "the degree to which committee systems perform the functions expected of them as legislative agencies" (p. 252). The definition given by Rosenthal is somehow different from the above three definitions. He relates effectiveness to the performance of the functions that are expected to be performed by oversight committees. As mentioned above, one of the functions of parliamentary committees is to conduct effective oversight. As a result, the Ethiopian parliamentary committees have a duty to conduct effective oversight with the objective of "ensuring that the executive bodies are carrying out their work in accordance with the national policies and strategies, decrees, regulations, and guidelines issued by the government

For this study, the goal approach (objective) and Rosenthal's definition of committees' effectiveness were applied. Therefore, based on the above committees' objectives and Rosenthal's definition of effectiveness, the fifth term of the Ethiopian parliamentary committees' effectiveness was assessed in relation to the ten common oversight functions listed above under section of oversight functions of the Ethiopian parliamentary committees.

Measuring the Effectiveness of Committees

Assessment of parliamentary committee's effectiveness is crucial for good governance. This has led a number of academics and professionals to develop a number of evaluation methods including passing significant bills, addressing significant issues, and blocking unimportant ones. However, while all of these methods could advance our understanding of how to evaluate committee effectiveness, they are not very useful to parliamentary committees because they lack a sense of measuring oversight functions (Kinyondo and Pelizzo, 2022).

Establishing the effectiveness criterion is a significant issue for assessing the committees' effectiveness. Notwithstanding the challenges in assessing legislative committee efficacy, researchers have attempted to do so by comparing it to a number of particular standards (Drewry, 1985; Marsh, 1986; Aldons, 2000; Monk, 2009; Njoroge, 2010).

Aldons (2000) developed a framework to measure the effectiveness of a parliamentary committee. To be rated effective, over 50% of key recommendations must be accepted and the government must provide a clear response. The methodology has limitations, such as relying solely on committee recommendations and responses, and not considering the quality of reports.

Rahman's 2008 study on parliamentary control and government accountability in South Asia, comparing Bangladesh, India, and Sri Lanka, used a four-point Likert scale to measure members' perceptions of parliament and committees' role in holding the government accountable.

Marsh (1986) used four criteria to assess the committees' effectiveness in a study on the British Parliament. The selection, scope, and significance of inquiry topics comprise the first criterion; the fundamental premise for effectiveness is that inquiry topics have to be pertinent and important. The way that investigations are carried out is the second requirement. This includes the sufficiency of the evidence gathered by committees, the resources gathered for study, the questioning style, their ability to involve interest groups, and, lastly, the timely completion of findings. Marsh's third metric is findings, which encompasses both the results' lucidity and the bipartisan process used to arrive at them. Because they show whether or not committees are prepared to criticise the government on major policies, these factors are crucial for evaluating committee performance. The impact of

reports and enquiries is the last criterion. Marsh (1986), however, notes that any committee work and the data they provide will be forgotten if the reports are not particularly discussed in parliament.

Njoroge's 2010 study on Kenyan parliamentary committees' effectiveness used Collegiate Project Services (CPS) score indicators to evaluate factors such as result, ownership, focus, team process, communication, leadership sharing, leadership support, and structure. The CPS scores measure qualitative results and convert them into quantitative figures. For each factor, a score ranging from 1 to 4 is accorded.

Mokgari and Pwaka (2018) study evaluated the effectiveness of oversight committees in Johannesburg using three KIIs and twelve qualitative questions to assess respondents' understanding of their roles, perceptions, and challenges. (Monk, 2009) suggests measuring committee effectiveness using four groups: government, legislature, stakeholders, and voters. The framework focuses on how many groups rate a committee as effective, with more indicating higher effectiveness. However, it lacks a function rating for effectiveness, indicating a minimum level of effectiveness.

Kinyondo, Pelizzo and Umar (2015) utilized a functional approach to assess the oversight effectiveness of five African parliaments, highlighting its multi-functional functions, such as coercive, negotiation, informative, legitimacy, and linkage. IPU developed a model to assess parliament effectiveness, based on surveys among stakeholders. It measures five principles: representativeness, transparency, accessibility, accountability, and effectiveness, ranging from 1 to 5 of Likert scale.

Aklilu et al. (2020) used a model to evaluate the effectiveness of the Ethiopian parliament in using its twelve oversight tools. They used a 1 to 5 scale, with higher mean values indicating less effectiveness.

Measuring the Effectiveness of the Ethiopian Parliamentary Committees

This study aims to measure the effectiveness of Ethiopian parliamentary committees using survey data from reliable sources like the HPRs. It proposes that committee effectiveness should be measured by the extent to which committees perform their oversight functions consistent with their objectives.

The study evaluates the effectiveness of the Ethiopian Parliamentary Committee using a decision-based model. The model involves surveying committees on a 1-to-5-point Likert scale. The effectiveness of committees is measured by 10 indicators: following up on government GTP, budget implementation, good governance, service delivery, civil service reform, human rights, and freedom of expression, enacted laws, audit findings, and mainstreaming functions. The eight dimensions measure the effectiveness of committees in implementing laws, audit findings, and mainstreaming functions.

The researcher used self-developed, validated measures from the IPU to assess the effectiveness of parliamentary committees (Coelho and Monteiro, 2015) in their oversight functions. In this case, higher mean values indicate more effective committees, while lower mean values indicate less effectiveness.

Research Methods Used

Research methods are the tools by which data is collected. We are unlikely to obtain high-quality data if research procedures are not properly designed and applied, which would provide a precarious basis for any review, assessment, or future plan (Kothari, 2004; Igwenagu, 2016). This study applied quantitative research methods. Quantitative cross-sectional survey methods are research techniques that are used to gather quantitative data, data that can be sorted, classified, measured. Surveys are a popular method of collecting primary data. The broad area of survey research encompasses any measurement procedures that involve asking questions of respondents. They are a flexible tool, which can produce both qualitative and quantitative information depending on how they are structured and analysed. In this section we focus on the quantitative use of surveys

Population and Sampling Techniques

The whole set of cases from which the researcher's sample was drawn is called the population (Taherdoost, 2016a). It is the object of research and consists of individuals, groups, and organizations (Bryman, 2016). Data obtained from the parliament's research unit (HPR, 2019) has shown that there were 10 standing committees with a total membership of 326. As a result, samples were taken from these 326 members of the committees based on random sampling technique. Since there was a high level of homogeneity among respondents, there was no need to target the entire population. That is, the more homogenous a population, the more valid the conclusions drawn from a small sample (Canada Audit and Accountability Foundation, 2023).

Sample Size Determination

Sample size determination is the act of choosing the number of observations that will be included in a statistical sample (Taherdoost, 2016). Different authors used different formulas to determine the sample size of the study. In this study, the sample size of the participants was determined based on the formula developed by (Yamane, 1973). Then, by applying a proportional and lottery method (Kothari, 2004) individual committee members were picked up from each subcommittee.

The formula is

$$n = \frac{N}{1 + Ne^2}$$

$$n = \frac{326}{1 + 326 (0.05)^2}$$

$$n = 179.61$$

n = required sample size.

N = the population size.

e = level of precision or sampling error.

According to the above formula, the actual sample size was 179.6 (180). This sampling number was distributed to each ten standing committees based on the size of each standing committee. On average, each committee had a share of 18 participants.

Instruments and Measures

Data collection tools refer to the devices or instruments that are used to collect data (Kabir, 2016). A questionnaire is a data collection instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents (Abawi, 2013). The questionnaires were designed based on various literature and empirical studies that deal with the topic under investigation. The items incorporated into the questionnaire generally included both closed-ended and open-ended items. The questionnaire has two major parts, such as general information about the respondents and the oversight functions of the committees. As a result, the study's questionnaires were self-developed.

These questionnaires were self-developed questionnaires and they were validated. Questionnaire validation is a process in which the developer reviews the questionnaire to determine whether it measures what it was designed to measure (de Yébenes Prous, Salvanés and Ortells, 2009). There are different types of validity for an instrument: logical or apparent validity, content validity, construct validity, and criteria validity. This study applies the logical or apparent validity method. According to de Yébenes Prous, Salvanés and Ortells (2009), logical or apparent validity refers to "the degree to which a questionnaire appears to measure that for which it was intended in the opinion of experts and the subjects" (p. 173). As a result, 20 people, i.e., scholars (5), professors (3), and members of parliamentary committees were validating the instrument. Following the validation, some questionnaires were removed and some were modified.

Particular attention was also given to the selection of scales for the questionnaires. Interval scales were used for the study. According to Pimentel (2019) most social science researchers prefer to use response categories that are on an odd scale (three, five, seven, or nine), because they are interested in the scenario in the middle response. In this study, a five-point scale was used for assessing the effectiveness level of committee effectiveness. As a result, 10 items taken from the HPRs rules and procedures (HPR, 2016), the values for each response item were presented as follows: 1 = very low; 2 = low; 3 = medium; 4 = high; 5 = very high for the effectiveness of committees on oversight functions which was adopted from Coelho and Monteiro (2015).

Reliability and Validity

A crucial step in evaluating the accuracy and quality of survey data is reliability analysis, which establishes the stability and consistency of a measuring tool or survey questionnaire over time and in various contexts. Cronbach's alpha was employed in this study to ascertain the level of internal consistency dependability.

Table 1: Reliability Test

Scales	Number of variables observed	Reliability coefficients (Cronbach Alpha)
Effectiveness	10	0.912

Source: Survey Data (2022)

Table 1 presents the results of testing the reliability and validity of the research questionnaire. Cronbach's alpha coefficients for the item was more significant than 0.7, indicating the internally consistent reliability of the questionnaire (Hair et al., 2019). The validity of the questionnaire was also confirmed through expert evaluation.

Ethical Considerations

Research ethics refers to the principles that we use to make decisions about what is acceptable practice in any research project (Rath, 2013). This study prioritized gaining participants' consent, developing trust, promoting research integrity, and guarding against misconduct. Ethical issues were addressed before, during, and after data collection, analysis, reporting, sharing, and storage. Confidentiality was maintained by disassociating names from responses during coding and recording processes.

RESULTS AND DISCUSSION

Results

Response Rate

The percentage of subjects who responded to the questionnaires or interviews is referred to as the response rate (Wambui and Gichuho, 2013). The response rates for the questionnaire were summarized as follows.

Table 2. Questionnaire Response Rate

Responses	No. questionnaires	Percentage
Distributed questionnaires	180	100%
Returned and usable questionnaires	178	98.9%
Unreturned questionnaires	2	1.1%

Source: Survey data, 2022.

The study involved 178 Ethiopian parliament members, with 180 questionnaires distributed. A response rate of 98.9% was collected from 178 respondents. The response rate is considered excellent for analysis and reporting, as it is above the recommended range of 50% for adequate analysis and reporting, 60% for good, and 70% or more for excellent results (Mugenda and Mugenda, 2003).

Description of Participants' Characteristics

In this part, the profiles of respondents, that is, committee members of the Ethiopian parliamentary committees were presented and discussed. The major points that have been used for the study are the demographic characteristics like sex, service year, academic qualification, and position on the committee.

Table 3. Profiles Of Respondents In Terms Of Sex, Education, Experience And Position

No	Characteristics of the Respondents		Frequency	Percent
1	Sex of respondents	Male	98	55.1
		Female	80	44.9
		Total	178	100
2	Educational background	Degree	37	20.8
		Masters	141	70.2
		Total	178	100
3	Experience (service year)	5 years	92	51.7
		10 years	62	34.8
		15 years and above	24	13.5
		Total	178	100

No	Characteristics of the Respondents		Frequency	Percent
4	Position in the committee	Chair person	15	8.4
		Member	163	91.6
		Total	178	100

Source: Survey data, 2022.

Table 3 shows respondents' sex, educational background, service year, and committee position. 98 (55.1%) are men, while 80 (44.9%) are women. The research has a 17 percent higher sex composition than the parliament, with 27.8% of MPs being female during the 5th term of the parliament. The study found that respondents had a high educational background, with 20.79% having a bachelor's degree and 79.21 percent having a master's degree. This high level of academic qualification enables them to understand questions and respond easily. The data shows that 51.7% of respondents have worked for five years, 34.8% for ten years, and 13.5% for 15 years and above. Over half of these respondents have served as committee members in parliament, providing a wider experience and knowledge base of committee functions and challenges. This indicates a significant proportion of respondents have worked in parliament for at least five years. The researcher analyzed respondents' positions within committees to determine if there was a difference in their perception of committee effectiveness. Results showed that 91.6% of respondents are committee members, with 8.4% being leadership members. This suggests that committee members may provide unbiased responses.

Description of the Oversight Functions of the Committees

Data obtained from the document review revealed that the Ethiopian parliamentary committees have two types of oversight functions: specific and common oversight functions. While specific oversight functions are functions that were given to specific committees to oversee a specific governmental agency or the Ministry, common oversight functions are oversight functions that were performed by all standing committees. These common oversight functions include following up on the Federal government's five-year plan, efficient budget utilization, good governance, public service delivery, civil service reform, human rights respect, information freedom, effective law implementation, audit findings, and mainstreaming issues. (HPR, 2016). This study focused only on common oversight functions of Ethiopian parliamentary committees aiming to assess the overall effectiveness level of the parliamentary oversight committees on such common oversight functions.

Description of the Effectiveness of the Committees

This section presents the study's results on the effectiveness of committees in performing ten common oversight functions including: oversight of the implementations of five-year GTP; effective and efficient budget utilization; external and internal good governance; expeditious and accountable service delivery; civil service reforms; reception for human rights; freedom of expression; enacted laws; audit findings; and mainstreaming issues.

Respondents were asked to describe their level of agreement on the effectiveness of their performance on the ten common oversight functions. Table 4 describes the summary results of the common oversight functions of the 5th term of the Ethiopian parliamentary committees. The study's total mean is 3.2, which is found under the category of 3 (in our case, medium) on the five-point Likert scale intervals (Pihie and Akmaliah, 2009; He, 2012; Pimentel, 2019). This indicates that the overall average of the respondents believed that the oversight committees were medium effective in performing the common oversight functions.

Two open-ended questions were asked of the respondents with the aim of understanding in performance measurement practice and in evaluating their performance in general. The first question was, "How was the committees' performance evaluated and measured?" Almost all respondents responded that the committee's performance was evaluated or measured based on "Gingema," which is finally approved by the coordinating committee. According to these respondents, committees were given a grade of "A" (high performance), "B" (medium performance), and "C" (low performance) which is a totally subjective criterion. The second question was "How do you evaluate the effectiveness level of your committee on oversight functions in general?" Some of the respondents said that their committee's effectiveness level was high. However, the majority of respondents responded that their committee's effectiveness level was medium. From this, we can understand that the data revealed that the effectiveness level of the fifth term of the Ethiopian parliamentary committees on common oversight functions was medium.

Table 4. The Effectiveness of Committees on Oversight Functions

oversight Functions Indicators	Total	Committees' effectiveness on oversight functions					
		very low n (%)	Low n (%)	Medium n (%)	High n (%)	Very high n (%)	Mean (SD)
Implementation of the 5 years gov't. GTP	178	---	33(8.5)	65(36.5)	80(44.9)		3.26 (. 754)
implementation of effective and economical budget utilization	178	---	36(20.2)	80(44.9)	62(34.8)		3.15(. 730)
implementation of external and internal good governance	178	----	12(6.7)	111(62.4)	55(30.9)	----	3.24 (. 566)
implementation of expeditious and accountable service delivery	178	---	43(24.2)	86(48.3)	37(20.8)	12(6.7)	3.10(. 844)
implementation of civil service reform and other change instruments	178	----	44(24.7)	63(35.4)	59(33.1)		3.22(. 897)
implementation of Respecting of Human rights	178		33(18.5)	99(55.6)	46(25/8)	----	3.07(. 664)
Implementation of freedom of information	178	----	32(18.0)	115(64.6)	31(17.4)	----	2.99(. 597)
implementation of the Effective implementation of enacted laws	178	---	45(25.3)	55(30.9)	78(43.8)		3.19(. 813)
implementation of Audit findings	178	----	36(20.2)	72(40.4)	70(39,3)		3.19(.750)
implementation of Mainstreaming functions	178	----	44(24.7)	49(27.5)	67(37.6)		3.33(. 961)
Total/ Mean							3. 17(.572)

Source: Survey Data Analysis, 2022.

Discussion of Research Results

The above table (Table 4) describes the summary of the results of the effectiveness level of the Ethiopian parliamentary committees on oversight functions.

The study found that Ethiopian parliamentary committees' effectiveness in the fifth term was medium, with a mean value of 3.17. Surprisingly, the committees' effectiveness was medium on all ten common oversight functions, averaging between very low and very high.

This finding, at least indirectly, is somewhat supported by the literature (Awel 2011; Damtew, 2015; Aklilu et al., 2020), which examines the effectiveness of the EFDRE parliament on oversight functions. It seems that the medium effectiveness level of the committees' effectiveness may be related to the principal's support for the committees. That is, if the principal (Parliament) did not use whatever actions were available to provide incentives for the agents (Tafirenyika) to conduct the effective oversight that the principal wanted (Gailmard, 2012). Furthermore, the findings indicated that the agents (Tafirenyika) had not performed effective oversight as the principal desired.

The functionalist theory of oversight suggests that effectiveness assesses the effectiveness of an oversight activity. The data shows that most oversight measures have similar effects on the medium effectiveness level of the Ethiopian parliamentary committee's oversight function. However, four measures have a lower contribution,

such as following up on budget utilization, service delivery, human rights respect, and freedom of information implementation.

Conclusion

The objective of this study was assessing the effectiveness of level of parliamentary committees in the Ethiopian parliament.

From the results of the discussion above, data from both closed-ended and open-ended questionnaires showed that committees were moderately effective in performing oversight functions, but also revealed a negative aspect in some areas. As a result, it can be concluded that the fifth term of the Ethiopian parliamentary committees' effectiveness level in performing oversight functions was medium. The results also imply that, despite their medium effectiveness, the committees have succeeded to some extent in carrying out their oversight duties, adding to the overall efficiency of parliamentary oversight in the Ethiopian parliament. However, this suggests that there is still a need to improve the effectiveness of parliamentary committees on oversight functions.

Recommendations

The researcher recommends recommendations for the Ethiopian parliament, committee leadership, committee members, and potential researchers regarding oversight functions.

First, the Ethiopian parliament's coordinating committee lacks objective performance measurement criteria, leading to subjective evaluations. The researcher recommends developing an objective instrument and applying various incentives to enhance competition and effective oversight among committees.

Secondly, the study found medium effectiveness of committees in oversight functions, but not equal attention to all indicators. The researcher recommends enhancing committee effectiveness and ensuring equal attention.

Thirdly, in order to ensure that parliamentary committees are able to fully and effectively carry out their functions, further efforts should be made to enhance the effectiveness of parliamentary committees.

Contribution of the Study

Besides the scholarly contributions, the current research may also have important practical implications. The study has the following practical applications:

First, the study has some practical and administrative implications and suggestions for higher officials of the parliament that would follow, as these were extracted from the empirical findings of the current study

Second, the study may contribute to having a clear performance evaluation practice at the parliamentary and committee levels. These may assist the House leadership in cascading strategic objectives from the legislature to committees and then to subcommittees.

Limitations and Suggestions

The study has some limitations. The first limitation is found in the fact that this paper has focused only on the effectiveness of the parliamentary committees on common oversight functions. However, each of the Ethiopian parliamentary committees has specific oversight functions. Accordingly, the study suggests conducting further research on those specific oversight functions.

The second limitation arises from the fact that this study was limited to the effectiveness of parliamentary committees at the Federal level and could not be generalized to other settings. So, to enhance external validity, the study suggests conducting future research efforts focusing on the effectiveness of regional council standing committees on their oversight functions.

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From Subsistence to Sustainability: Examining Farmer Willingness to Adopt Climate-Smart Agricultural Technologies for Apple Cultivation evidence from Himalayan state of Jammu and Kashmir, India

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Abstract

Apple is one of the high-value agricultural commodities in Kashmir. It is one of the major fruit crops in the Union Territory of Jammu and Kashmir, India, in terms of potential growing area, production, and domestic consumption. The overall fruit production has increased by 3.95 LMTs during 2021–22, i.e., from 20.36 LMTs in 2020–21 to 24.31 LMTs, recording a growth of 19.39 percent. The climate smart agriculture technology adoption in the form of high-density apple plantation covered an area of 6090.91 ha in the financial year 21–22, registering a growth of 591% over the previous year. The paper aims to investigate the relationship between climate smart agriculture technologies and farmers adoption behaviour in Himalayan state of Kashmir, India. It proposes a novel extension of UTAUT model. The paper uses structure equation modelling to estimate the influence of factors on intention to adopt climate smart agriculture technologies for farm production in Kashmir. The paper presents an empirical insight that farmers extension contacts, perceived climate risk, government subsidy and facilitating conditions positively influence farmers intention to adopt CSA technologies for apple farming in Kashmir. Furthermore, perceived cost and social influence was found to be insignificant in determining farmers intention to adopt CSA technologies. This model more accurately predicts CSA technology adoption by identifying the factors that either encourage or hinder farmers from adopting it. Researchers have previously studied the adoption of CSA technology in Jammu and Kashmir from a socioeconomic perspective. Previous studies have overlooked other factors that influence CSA technology adoption. We also recommend strengthening factors like cost and bank credit to enhance the adoption of CSA technologies. Climate-smart agriculture technology has immense potential to enhance food security, environmental preservation, and agricultural productivity.

Keywords: Sustainability: Climate: Technology, UTAUT: Adoption Behaviour

Introduction

Climate change poses a severe danger to food security, especially in developing nations (Campbell *et al.*, 2014). In tropical regions, severe temperatures and little rainfall jeopardize agricultural development (Aydinalp and Cresser, 2008; Tripathi, 2018). Climate change is linked to a heightened incidence of agricultural pests and diseases, as well as a reduction in soil fertility, resulting in crop failures and diminished output (Sidique and Hadi, 2016). Forecasts indicate a probable loss in agricultural output of 4.5% to 9% in medium-term (2010–2039) and a decline of 25% or greater in long long-term (2070–2099) (Prabakaran, Vaithiyanathan and Ganesan, 2018). Climate-Smart Agriculture (CSA) technologies are advocated as strategies for both adaptation and mitigation of the adverse effects of climate change and serve as a fundamental basis for attaining Sustainable Intensification (Taylor, 2018). Climate-Smart Agriculture (CSA) is a farming methodology that enhances farmers' resistance to climate change, improves their livelihoods, and bolsters food security (Lipper *et al.*, 2014).

Although Climate-Smart Agriculture (CSA) is extensively advocated by various private and public sector entities and integrated into numerous national policy frameworks), its adoption among smallholder farmers in union territory of Jammu & Kashmir remains minimal and inconsistent, with many technologies underutilized. Notwithstanding these advantages in achieving sustainability objectives, prior studies reveal a sluggish and predominantly restricted long-term adoption of Climate-Smart Agriculture (CSA) technologies by smallholder farmers (Mahdi *et al.*, 2021). This adoption is a crucial prerequisite for the effective implementation of CSA and the sustainability of agricultural systems. This underscores the necessity for further investigation into the factors influencing CSA adoption in Jammu and Kashmir.

The Himalayan area is particularly vulnerable, as it is prone to catastrophic weather events in both the present and the future due to climate projections (Nandargi and Dhar, 2011; Romshoo *et al.*, 2018; Para *et al.*, 2020). The Kashmir Valley, spanning approximately 15,000 km², is a nappe zone situated in northern India, sandwiched between the Pir Panjal Range (Lat: 73°54'–75°35' E; Lon: 33°22'–34°42' N) and the Greater Himalayas (Rashid *et al.*, 2020). The Kashmir region, which is in the western part of the Himalayan range, is

expected to have seen much more frequent unpredictable weather events by the end of this century because of ongoing warming (Gujree et al., 2017; Rafiq & Mishra, 2018).

The Union Territory of Jammu and Kashmir continues to have an agrarian economy. Nearly 70 percent of the population is directly or indirectly involved in agriculture. According to the latest data, agriculture in Jammu and Kashmir contributes 17.2 percent to the total gross state domestic product (GSDP), and its growth rate of 9 percent is substantially higher than the national average of 2.9 percent (Economic Survey-2023,). Among the agricultural activities, horticulture is the most important driver of the growth rate, contributing 40 percent to the total output value from agriculture in Jammu and Kashmir (Hassan et al., 2020; Shah et al., 2022).

Jammu and Kashmir primarily grows apples on around 51% of the 2.72 lakh hectares used for all other temperate fruit growing in the state. Presently, the state contributes 75 percent of total Indian apple production, with an average yield of commercially important apple cultivation per unit area that is the highest in the country, ranging between 10 and 13 t/ha, but compares poorly with yields of 20–40 t/ha in horticulture advanced countries (Wani *et al.*, 2021). The Kashmir valley's temperature and other agro-ecological features are ideal for cultivating a wide variety of apples, as well as other temperate fruits. The apple industry directly or indirectly engages over 30 lakh people, or roughly 5–6 lakh households, and generates an annual revenue of Rs. 8000 crores for the state (Shah et al., 2022).

Recent years in Kashmir have seen abrupt and intense weather patterns that have badly damaged ecosystems as well as the economy (Rafiq and Mishra, 2018; Romshoo *et al.*, 2018). Two of these unpredictable snowfall events occurred in Kashmir Valley in the late autumn of 2018 and 2019, both of which devastated apple orchards throughout the valley (Rashid *et al.*, 2020). This is significant because the government implemented a sustainable intervention to boost the value of the horticulture industry from INR 60 billion to INR 300 billion (Hassan, 2021; Mir & Raja, 2021.). The government has launched the heavily subsidised High Density Apple Plantation (HDAP), a subset of climate smart agriculture intervention initiative with plant protection mechanisms such as anti-hail netting, drip irrigation, and trellis systems made of metallic or wood poles and wire in response to recent losses and to increase apple output.

Apple is one of the high-value agricultural commodities in Kashmir (Hassan, 2021; Mir & Raja, 2021., 2022). It is one of the major fruit crops in the Union Territory of Jammu and Kashmir, India, in terms of potential growing area, production, and domestic consumption. Indian states, viz., Himachal Pradesh, Uttarakhand, and Arunachal Pradesh, including the union territory of Jammu and Kashmir (J&K), provide a niche for commercial apple cultivation (Mir & Raja, 2021.). The area under fruit crops has increased by 6978 ha, i.e., from 334719 ha in 2020–21 to 341697 ha in 2021–22, thereby recording a growth of 2.08 percent (Economic Survey–2023). The overall fruit production has increased by 3.95 LMTs during 2021–22, i.e., from 20.36 LMTs in 2020–21 to 24.31 LMTs, recording a growth of 19.39 percent. The climate smart agriculture technology adoption in the form of high-density apple plantation covered an area of 6090.91 ha in the financial year 21–22, registering a growth of 591% over the previous year (Economic Survey 2023).

The aims of the research paper are to demonstrate the application of an UTAUT model to unveil factors affecting acceptance and user behavior of climate smart agriculture technology adoption among farmers of Kashmir. Previous studies have overlooked the behavioral aspects of farmers' adoption process and focused more on binary variables. This study adds novelty by extending UTAUT model to predict accurately the factors affecting CSA technologies among farmers.

Review of Literature

The Unified Theory of Acceptance and Use of Technology (UTAUT) model was created by (Venkatesh *et al.*, 2003). It is a framework for thinking about how performance expectation, effort expectation, social influence, facilitating conditions, and demographic factors affect intention and adoption of new technology. To tackle this issue, (Venkatesh *et al.*, 2008, 2012; Venkatesh, L Thong and Xu, 2016) developed the Adapted Unified Theory of Acceptance and Use of Technology (AUT2) model by adding new constructs. This study modified the UTAUT by incorporating perceived cost, perceived climate risk and farmer extension contacts to the model.

Social Influence (SI)

Social influence refers to the extent to which individuals perceive the opinions or beliefs of important people in their social circles regarding the use of a particular technology (Moussaïd *et al.*, 2013). The social environment, including friends and family, somewhat influences the operational development of a farm (Foster & Rosenzweig, 1995). Furthermore, (Rieple and Snijders, 2018) found that a farmer's current experiences with new technology significantly influence their future use of it. The discussion allows us to formulate the following hypothesis as:

H1: Social Influence has a significant impact on farmers acceptance of climate smart agriculture technologies.

Perceived Cost

The phrase "perceived cost" (PC) refers to how people calculate the costs involved in putting new technology into use (Shafinah *et al.*, 2013; Faridi, Kavoosi-Kalashami and Bilali, 2020). There is strong evidence that implementation of water and soil conservation measures is negatively correlated with perceived cost (Schaafsma *et al.*, 2019). Furthermore perceived cost is defined all the material expenses (financial, time-related, etc.) and social costs that the farmers anticipate incurring because of new agriculture technology adoption (Arfi *et al.*, 2020). The discussion allows us to formulate the following hypothesis as:

H2: Perceived cost has a significant impact on farmers acceptance of climate smart agriculture technologies

Perceived Climate Risk

climatic risk encompasses local circumstances, such as exposure, climatic risks, and susceptibility. Climate risk information encompasses data and insights into the possible effects and probabilities of climate and weather-related trends and occurrences (Arbuckle, Morton and Hobbs, 2015). Perceived risk significantly influences the acceptance of new technologies, according to research on perceived climate risk (PCR) (Poortvliet *et al.*, 2018). Research reveals that individuals are more inclined to adopt conservation measures when they perceive a higher risk of adopting water and soil conservation measures (Faridi *et al.*, 2020). Additionally, research has shown that the effective creation of technological breakthroughs depends on people's perceptions of risk and benefit (Poortvliet *et al.*, 2018). Similarly, a good correlation between opinions on climate change and the application of adaptation strategies has been found by (Arbuckle, Morton and Hobbs, 2015). The discussion allows us to formulate the following hypothesis as:

H3 Perceived climate risk has a significant impact on farmers acceptance of climate smart agriculture technologies.

Facilitating Conditions

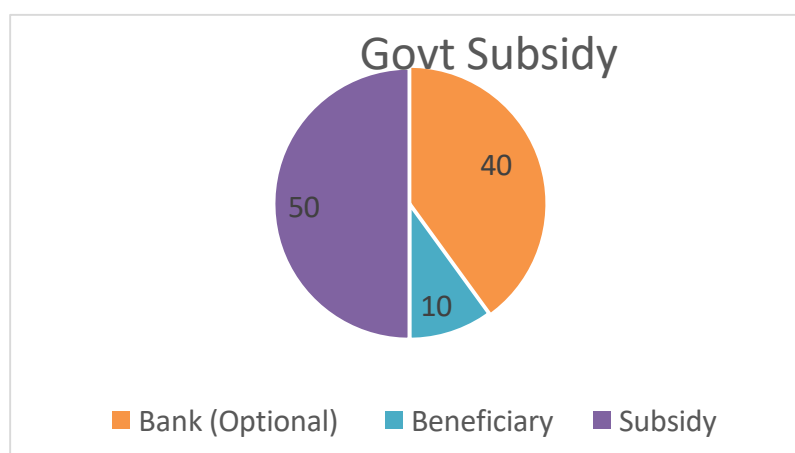
The degree to which a person feels that the technological and organizational infrastructure is in place to assist and make it easier for them to utilize a certain system is known as the facilitating condition (Venkatesh and Bala, 2008). The concept of enabling circumstances encompasses all the necessary operational prerequisites for the initial use of new technology. According to (Martins, Oliveira and Popovič, 2014) the supportive atmosphere influences both the adoption process and its usage. Climate smart agriculture technology acceptance described as "the possibility that a person may engage in certain behaviors in the future under certain conditions and do something," is frequently linked to technology usage (Venkatesh *et al.*, 2003). Drawing from the discussion above, we can propose the following hypothesis:

H4: Facilitating conditions have a positive impact on user behavior of climate smart agriculture technologies.

Government Subsidy

The High-Density Apple Plantation Scheme, a subset of climate smart agriculture technologies package is a fully state-funded initiative, aims to enhance productivity and production while augmenting farmer income (HDAP-Scheme, 2017). The broader contours include reducing pest and fertilizer usage and minimize water usage. under the scheme, funding is split 50:50 between the government and the farmers.

Figure 2



H5: Government subsidies have a significant impact on farmers acceptance of climate smart agriculture technologies

Farmers Extension Contact

Agricultural-extension services are defined as "the entire set of organizations that facilitate and support people engaged in agricultural activities to solve problems and obtain information, skills, and technologies to improve their livelihoods and well-being"(Davis et al., 2020).Extension services offer farmers timely and pertinent information to help them solve farming-related issues and make better agricultural decisions (Kassem et al., 2021).The quality of the extension and advisory services offered determines how well extension programs work to achieve a sustainable development strategy (Kishore et al., 2018). Extension services offer farmers timely and pertinent information to help them solve farming-related issues and make better agricultural decisions(Cawley et al., 2015; Moyo and Salawu, 2018). From the above discussion we propose the following hypothesis as:

H6: Farmer extension contacts have a positive impact on user behavior of climate smart agriculture technologies.

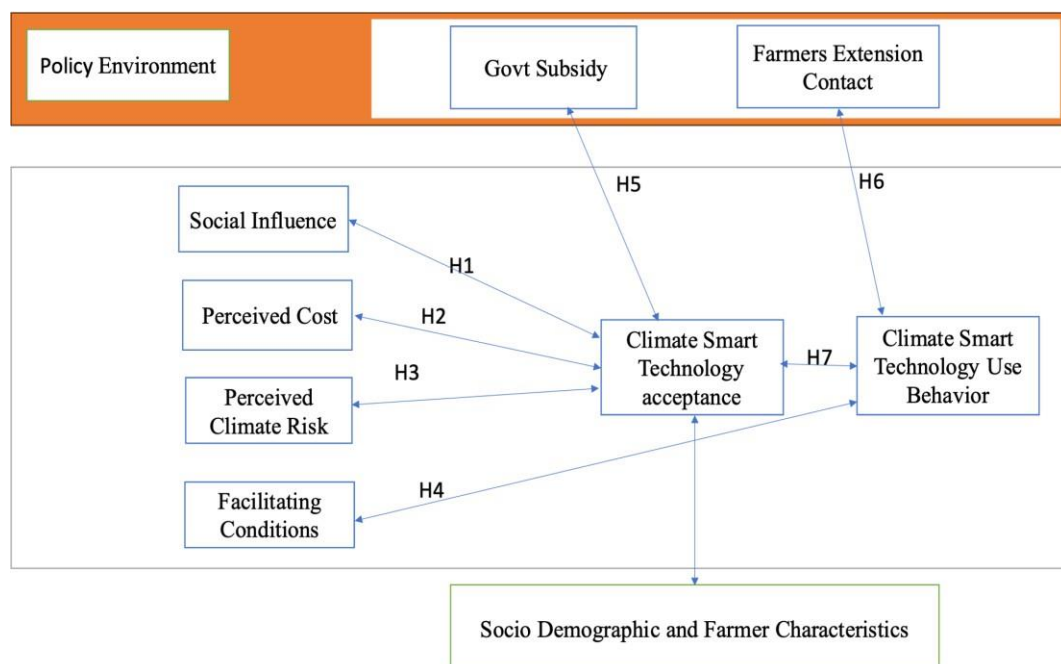
Research Questions.

1. What are the factors that influence the farmers acceptance and use behavior of climate smart agriculture technologies?
2. How effective are policy environment in promoting farmers acceptance and user behavior of climate smart agriculture technologies?
3. How do social demographic and farmer characteristics effect on smart climate technology acceptance?

Research Objectives:

1. To ascertain the factors that influence farmers acceptance and use behavior of climate smart agriculture technologies
2. To study the influence of social demographic and farmer characteristics effect on climate smart technology acceptance
4. To determine the role of policy environment (govt. subsidy and farmer extension contact) on farmers acceptance and user behavior of climate smart agriculture technologies?
3. To enhance the strategies and suggestions on climate smart technology acceptance

Fig 1 Proposed Conceptual Model



Research Methodology

Variable Measurement and Data Collection

Previous studies on the adoption of new technologies by ('davis1989' ; Zhou, Lu and Wang, 2010; Clark et al., 2018) provided the survey questions. A few professors from Jamia Millia Islamia University in New Delhi, India, and Prof Glynn Jones from New Castle University and few horticulture officers from Jammu and Kashmir helped in questionnaire formulation. A survey questionnaire was prepared in English to collect data. The experts' perspectives guaranteed that the survey questions reflected farmers' perspectives on the implementation of climate smart agriculture technologies. The data was collected using questionnaires and interview methods emphasis was laid to translate the questionnaire in local language to make the respondents better understand the questions. We measured the survey indicators using a five-point Likert scale, with "5" representing strongly agree and "1" representing strongly disagree, except for demographic variables. We conducted a pilot study with 75 farmers from five different districts of Jammu and Kashmir to test the survey questionnaire.

Sampling Technique

The present study was conducted in the union territory of Jammu and Kashmir-the northern most region of India. Five districts from Kashmir valley namely, Anantnag, Baramulla, Budgam, Ganderbal and Shopian were selected purposively. A multistage sampling procedure was adopted for the selection of districts, horticultural zones, villages, and sample orchardists. From the selected districts, three horticultural zones from each district having maximum area under apple cultivation were selected purposively. From each horticultural zone, five villages were selected having maximum area under apple cultivation. A list of apple growers (orchardists) of selected villages was obtained from concerned Horticultural Development Offices and a sample of different growers (orchardists) having marginal, small, medium, and large land holdings, were selected proportionately from selected villages. Thus, a total of 353 growers (orchardists) were selected purposively from seventy-five selected villages with the following formula.

$$n_i = \frac{N_i}{N} n$$

Where, n_i = Number of sampled apple growers in each village, n = Total number of apple growers selected for the present study (353), N = Total number of apple growers in sampled villages, N_i = Total number of apple growers in i th village.

Table 4. 1 District wise sample

	Frequency	Percent	Valid Percent
Anantnag	79	22	22
Baramulla	115	33	33
Budgam	53	15	15
Ganderbal	25	7	7
Shopian	81	23	23
Total	353	100.0	100.0

Data Analysis and Results

The data analysis process for this research involved four steps. We conducted descriptive statistics in the first phase to understand the sample's structure. We received a total of 353 out of 400 responses from five major apple-producing districts of the Union Territory of Jammu and Kashmir (Baramulla, Budgam, Ganderbal Shopian, and Anantnag); we discarded 47 responses due to missing data points, this research study examined 353 valid responses, 78% from male participants and 22% from female participants, ensuring the results were free from gender bias. In addition, 38% of the participants were from the age group 35–45 years, followed by 26% above 45–55 years, 19% between 25–35 years, 10% above 55 years, and 7% below 25 years. In this survey, the income range of farmers was less than 1 lac = 1%, 1 lac to 3 lac = 9%, 3 lacs to 5 lacs = 16%, 5 lac to 10 lac = 40%, and above 10 lac = 34%. furthermore, the landholding of farmers lies between 1 hectare (12%), 1-2 hectares (27%), 2-4 hectares (32%), and 4–24 hectares (29%). Table 1.1 summarizes demographic variables relevant to the collected and analysed sample.

Table 1.1: Demographic profile

Characteristics	Category	Frequency	Percentage
Gender	Male	274	78
	Female	79	22
	Total	353	100
Age	Below 25	23	7
	25-35	67	19
	35-45	133	38
	45-55	93	26
	Above 55	37	10
	TOTAL	353	100
District	Baramulla	115	33
	Budgam	53	15
	Shopian	81	23
	Ganderbal	25	7
	Anantnag	79	22
	Total	353	100
Income	Less than 1,00,000	5	1
	1,00,000 – 3 00,000	31	9
	3,00,000 – 5,00,000	56	16
	5 00,000 - 10, 00,000	140	40
	10, 00,000 or above	121	34
	Total	353	100
Land Holding	Marginal (up to 1 Hectare/8 Kanals)	42	12
	Small (1-2 hectare/ 8- 16 Kanals)	96	27
	Medium (2-4 hectare/ 16-24 Kanals)	109	32
	Large (4 and above/ 24 Kanals and above)	103	29
	Total	353	100

Reliability And Validity Analysis

In the second round of data analysis, we evaluated the validity and reliability of the constructs. We utilised the statistical software programmes SPSS 26.0 and AMOS 20. to analyse suggestions for the assessment of reliability and validity components. We also subjected all retained items to tests for construct reliability and validity. Both composite reliability (CR) and average variance extracted (AVE) were considered, as suggested by (Hair, 2009). Table 1.2 reveals that all constructs have CR values above 0.70 (Fornell and Larcker, 1981). Social influence recorded the largest CR value, while perceived benefit had the lowest value. All constructs have an acceptable value of AVE higher than 0.50, as suggested by (Fornell and Larcker, 1981) and (Hair *et al.*, 2012). Social influence (0.935) had the highest AVE value, while perceived climate risk (0.769) had the lowest value.

Table 1.2 Reliability and Validity Analysis

	CR	AVE	MSV	MaxR(H)	PERC	FAC	GSUBB	FEXCC	USB	S0I	CSAT	PERCR
PC	0.865	0.684	0.016	0.904	0.827							
FC	0.954	0.838	0.262	0.961	0.023	0.915						
GSUB	0.947	0.817	0.114	0.961	0.032	0.147	0.904					
FEXC	0.935	0.783	0.171	0.943	0.046	0.253	0.238	0.885				
UB	0.931	0.77	0.35	0.931	0.066	0.512	0.286	0.336	0.878			
SI	0.954	0.874	0.122	0.975	0.128	0.101	0.143	0.349	0.256	0.935		
CSAT	0.91	0.771	0.35	0.91	-0.032	0.423	0.337	0.251	0.592	0.188	0.878	
PCR	0.808	0.592	0.176	0.869	-0.025	0.419	0.178	0.413	0.338	0.152	0.379	0.769

Measurement Model

In the third step, confirmatory factor analyses were evaluated to make sure there was a suitable level of model fitness along with construct validity and reliability. As seen in Table 1.3, a number of the fit indices of the measurement model were found to be within their acceptable level (GFI: Goodness-of-Fit Index=.918; AGFI: Adjusted Goodness-of-Fit Index=.896; CFI: Comparative Fit Index=.984; CMIN/DF: Normed Chi-Square=1.420; NFI: Normed-Fit Index=.949; and RMSEA: Root Mean Square Error of Approximation=.035). Therefore, the model has adequate level of model fitness as all fit indices were within acceptable level as suggested by (J. Hair, 2009; Tabachnick & Fidell, 2007).

Table 1.3: Results of Measurement Model.

Fit indices	Cut off point	Model Fit (Measurement model)	Result
MIN/DF	≤3.000	1.420	Accepted
GFI	≥0.90	.918	Accepted
AGFI	≥0.80	.896	Accepted
NFI	≥0.90	.949	Accepted
CFI	≥0.90	.984	Accepted
RMSEA	≤0.08	.035	Accepted

Structural Model

Before proceeding with the structural model analysis, we must use Harman's single-factor test (1976) to prevent any issues related to the common method bias. We used SPSS 26 to retrieve eight latent constructs and their unremoved items for Harman's single-factor test. This value was less than the recommended one (< 0.50) (Podsakoff *et al.*, 1990). As a result, it appears that there was no problem with the common method bias.

Variance inflation factors (VIF) were checked to make sure there wasn't a multicollinearity issue between the main dependent and independent constructs. All the values found were within the recommended level of (< 10)

We tested the structural model of SEM in the last stage to verify the conceptual model and its associated hypotheses. Like the measurement model, we observed that all fit indices of the structural model, GFI = 0.911, AGFI = 0.890, NFI = 0.945, CFI = 0.981, CMIN/DF = 1.505, and RMSEA = 0.038, were within their acceptable levels (J. Hair, 2009).

Table 1.4 Results of Structure Model

Fit indices	Cut off point	Model Fit (Structure Model)	Result
CMIN/DF	≤ 3.000	1.505	accepted
GFI	≥ 0.90	.911	accepted
AGFI	≥ 0.80	.890	accepted
NFI	≥ 0.90	.945	accepted
CFI	≥ 0.90	.981	accepted
RMSEA	≤ 0.08	.038	accepted

Hypotheses Testing

The main causal paths were tested using path coefficient analyses as seen in Table 1.4. The main factors of adopted UTAUT namely GSUB), shows (CR=.5.057), $P < 0.001$), PCR (CR= 4.449, $P < 0.001$), , SI (C. R= 2.106, $P < 0.05$) were found to have a significant impact on farmers intention to adopt climate smart agriculture technology , while as PC (C. R= -0.774, $P > 0.05$) shows negative and insignificant impact on farmers intention to adopt climate smart agriculture technologies

Furthermore FEXC (CR=3.303 $P < 0.001$), FC (CR=6.43 $P < 0.001$) and CSTA (CR=8.734 $P < 0.001$) were found to have a significant impact on use behavior of climate smart agriculture technologies. Therefore, except for H2, all other research hypotheses (H1, H3, H4, H5, H6, and H7) were supported.

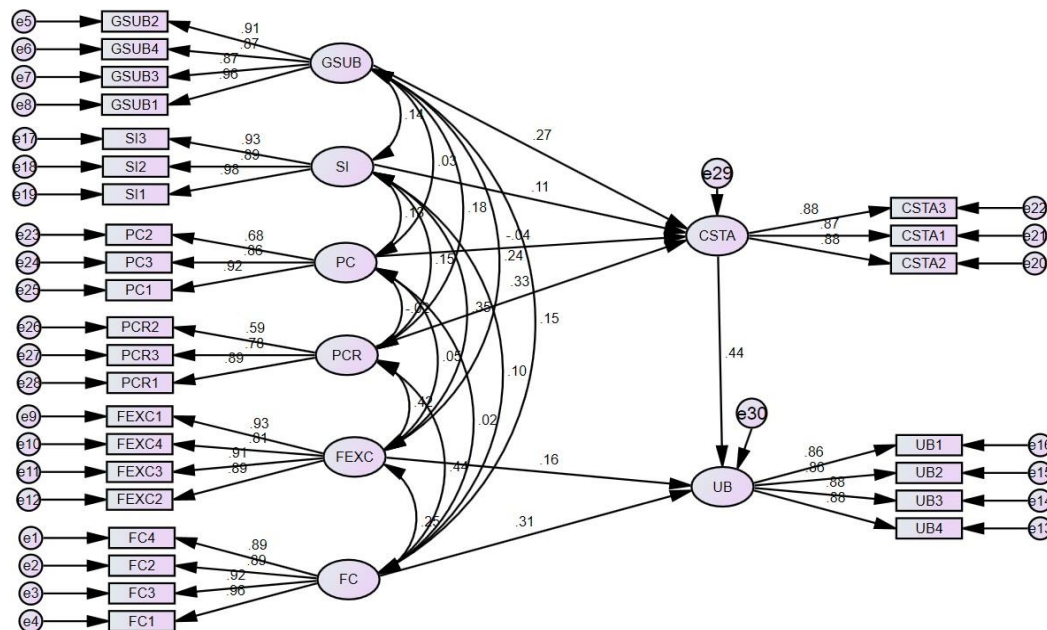


Table 1.5. Hypothesis Testing

			Estimate	S.E.	C.R.	P	Decision
CSTA	<-	GSUB	0.261	0.052	5.057	***	Accepted
CSTA	<-	SI	0.096	0.046	2.106	0.035	Accepted
CSTA	<-	PC	-0.048	0.062	-0.774	0.439	Not Supported
CSTA	<-	PCR	0.533	0.098	5.449	***	Accepted
UB	<-	CSTA	0.488	0.056	8.734	***	Accepted
UB	<-	FEXC	0.169	0.051	3.303	***	Accepted
UB	<-	FC	0.347	0.054	6.43	***	Accepted

Discussion

This study seeks to identify the key factors that influence farmers' intentions to adopt climate-smart agricultural technologies. As shown in Fig. 2, the conceptual model was also able to predict a significant portion of the

variance in farmers' adoption climate smart agriculture technologies with an R² value of 0.63. This, in turn, supports the predictive validity of the current study model.

First, farmers' perceived climate risk has the strongest influence on their intention to use climate-smart agricultural technologies (0.33), making it the strongest determinant of climate-smart agriculture adoption (Arbuckle, Morton and Hobbs, 2015). This finding is consistent with (Bunn *et al.*, 2015; Aryal *et al.*, 2018; Rodríguez-Barillas, Klerkx and Poortvliet, 2024). Agriculture in Kashmir valley is susceptible to weather vagaries and horticulture crops like apple has been the prime victim of climate change. uneven rains and cold in spring season led to late or reduced flowering and early snowfall in the month of November in recent years has led loss amounting to millions of dollars.

State intervention in terms of government subsidy has been an important determinant in motivating farmers to adopt climate smart farming in recent years. Government subsidy was found to be the second important determinant of farmers' intention to use climate-smart agricultural technology (0.27). This result is consistent with previous studies (Liu and Liu, 2024) that the government encourages (Zhang *et al.*, 2017; SHI, PAUDEL and CHEN, 2021). Continuous policy support in terms of subsidy has enhanced the pace of climate smart agriculture practices in Kashmir for both sustainability and productivity.

Farmer extension contacts are pivotal in demonstrating the benefits of new technology to farmers. It was found that farmers' extension contacts positively and significantly influenced how they used climate smart agriculture technology (0.16) (Silva, 2016; Suvedi, Ghimire and Kaplowitz, 2017; Kassem *et al.*, 2021). Kisan Kendras have been outreaching to farmers with the help of horticulture extension officers to demonstrate new and sustainable technologies along with making the adoption of climate smart agriculture technology adoption hassle free and one stop solution for farmers.

Facilitating conditions has a significant and positive impact on the use behaviour (0.31) of climate-smart agricultural technologies. The results are consistent with earlier studies (Schukat and Heise, 2021; Wiliam *et al.*, 2022). Climate smart agriculture technology adoption has been demarked as one of the high priority sectors in doubling farmers income. Keep in consideration the eco fragile landscape of Kashmir valley, the administration has been a proactive facilitator in climate smart agriculture technology adoption process.

Social Influence was found to significant factor in farmers CSA technology adoption. These results are consistent with earlier studies of (Moussaïd *et al.*, 2013; Ramirez, 2013). It is pertinent to mention that farmers are get influenced by their friends and relative's positive trade-off about CSA technology adoption. The fear of missing out plays an important role in CSA technology adoption among other farmers.

Farmers' intention to adopt climate-smart agricultural technologies showed an insignificant relation with perceived cost (-0.04). These finding are supported by earlier studies of (Arfi *et al.*, 2020; Klerkx & Rose, 2020). Cost of climate smart agriculture technology has no bearing on the adoption decision of the farmers because of government subsidy provided in up taking the technology. State intervention reduces the burden from the farmers shoulders leaving them with more disposable income.

The final behaviour intention has a positive and significant impact on farmers' use of climate-smart agricultural technologies (0.44) (Schukat and Heise, 2021; Wiliam *et al.*, 2022).

Conclusion, Implications and Future Research Direction

Climate-smart agriculture technology has immense potential to enhance food security, environmental preservation, and agricultural productivity. Researchers have previously studied the adoption of CSA technology in Jammu and Kashmir from a socioeconomic perspective. Previous studies have overlooked other factors that influence CSA technology adoption. This study extended and adopted the Unified Theory of Acceptance and Use of Technology (AUTAUT) model. This model more accurately predicts CSA technology adoption by identifying the factors that either encourage or hinder farmers from adopting it. Therefore, throughout the CSA technology innovation process, providers and regulators must consider the relationship between technological features and farmers' demands. There should be an effort to contact end users and other interested stakeholders early in the invention process to ensure efficient coproduction of CSA technologies that meet end-user expectations.

The study provides novel findings which can be incorporated in other countries to understand the factors affecting climate smart agriculture technology adoption among farmers. Despite this the study has few limitations as the area of study was limited to Kashmir valley. Future research can be built on these factors and increased the scope of study by doing comparative study of two states and increase the sample size. Along with that an integrated model can be applied where in factors like bank credit, Continuous policy support, Task technology characteristics and social media exposure can be explored in determining farmers intention to adopt new technology.

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Service Quality Gap Analysis Based on Servqual Model With A Case Study In Commuters Of The Metro Rail Transportation System In Kochi.

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Abstract

Even though service quality is a crucial component of public transportation, very little research has been conducted on the subject. Therefore, this study aims to analyse the service quality gap in the transportation service provided by Kochi metro rail transportation system by using SERVQUAL model. This research study also aims to study the influence of age on passengers' expectation and perception regarding service quality of Kochi Metro Rail. based on secondary and primary data. Data from 384 samples were collected by using purposive sampling method. We analysed the data collected from respondents with IBM SPSS software. Descriptive statistics, Gap Analysis, Paired sample t-test, Tukey HSD test, Pillai's Trace test, Wilks' Lambda test etc. were used to test the hypotheses. The study result found that the majority of the regular passengers having higher expectation regarding the service quality of the Kochi metro, but unfortunately perceived service quality was not much satisfactory based on passengers' opinion when compared to their expectation level. The results of the study show that, among the five dimensions of service quality, empathy shows the highest gap score. It has been found that age of the commuters significantly influences their service quality perceptions.

Keywords: Service Quality, Service Quality Gap, SERVQUAL, Perceived Service Quality

Introduction

The majority of corporate activity in the global economy is concentrated in the service sector. Several services, including lodging, medical care, and transportation, are the main sources of income for the companies. Service companies concentrate on gaining the trust and happiness of their customers by providing them with excellent value and high-quality services. Offering quality services at fair prices is a crucial factor in determining customer satisfaction. Customer satisfaction not only contributes revenue to the business but also growth and corporate success. Increased market share, profitability, positive word-of-mouth, and customer intention are all correlated with higher levels of customer satisfaction. The ability of a business to meet consumer expectations and maintain its competitiveness can be directly impacted by service quality, regardless of the industry. Parasuraman, Zeithaml, and Berry (1985) focused on customer expectations and perceptions in evaluating service quality. According to the researchers, service quality is "the degree and direction of discrepancy between customer perceptions and expectations. Lewis and Booms (1983) highlight the alignment between service delivery and customer expectations as a key determinant of service quality. According to the researchers, service quality is "a measure of how well the service level delivered matches customer expectations. Zeithaml et al. (1990) propose a comprehensive framework for understanding service quality, which consists of five dimensions like, tangibles, reliability, responsiveness, assurance, and empathy.

One of the most significant service industries that improves both the general standard of living and the economy is transportation. There have been so many incredible developments in the transportation industry. Mass rapid transit systems, including metro trains, monorails, bus rapid transit systems, etc., were developed in our nation to give citizens a higher quality and better mobility experience. They are renowned for making travelling easier, faster, and safer for people to move around. The introduction of metro rail has shown to be beneficial for society during rapid population growth. Due to the rapid urbanization of Indian cities, mass rapid transit systems are urgently needed. However, the fact is that, despite mass rapid transit's benefits, people's attitudes toward it haven't exactly improved. For a variety of reasons, fewer people are using metro rail for their transportation needs. This research study tries to analyze service quality gap in Kochi Metro Rail Transportation System by using SERVQUAL model. This research study also aims to study the influence of age on expectation and perception of passengers regarding service quality of Kochi Metro Rail.

Review of Literature

Service Quality

Service quality is a multidimensional concept that refers to the overall level of excellence or satisfaction experienced by customers to the services provided by an organization. The service-profit chain of Heskett et al. (1994) emphasizes the link between service quality, customer satisfaction, loyalty, and financial performance. A study conducted by Robert Jonson (1995) identified some satisfiers and dissatisfiers in service quality. According to the researcher, the predominantly satisfying determinants are attentiveness, responsiveness, care and friendliness and the dissatisfiers are integrity, reliability, responsiveness, availability and functionality. Lee

et al. (2000), studied the relationship of perceived service quality and customer satisfaction. The result shows that perceived service quality is an antecedent of satisfaction, rather than vice versa. Researchers have reported a consistent association between service quality and customer satisfaction (Woodside et al., 1989, O Mahamad, & T Ramayah, 2010, MV Ngo & HH Nguyen, 2016, E Sivadas, & JL Baker-Prewitt, 2000, H Oh, 1999, P Arora & S Narula, 2018,)

Service Quality in Public Transportation

Public transport plays a pivotal role in modern urban transportation systems, providing mobility options to millions of people worldwide. Service quality is a crucial aspect of public transport systems, influencing passenger satisfaction, mode choice decisions, and overall system performance. Hensher and Stanley (2020) conducted a comprehensive review of public transport passenger satisfaction and service quality measurement. The study analyzed various dimensions of service quality, including reliability, accessibility, comfort, safety, and customer service. It highlighted the importance of understanding passenger perceptions and expectations in evaluating service quality. Teixeira et al. (2019) developed and validated the Public Transport Service Quality Scale (PTSQS), a tool specifically designed for assessing service quality in public transport contexts. The study identified dimensions such as accessibility, reliability, comfort, safety, and tangibles as crucial factors influencing passenger perceptions of service quality. Kamruzzaman et al. (2018) investigated the relationship between service quality, service frequency, and car ownership in the context of a public transport priority policy in Brisbane, Australia. The study found that improvements in service quality, particularly reliability and accessibility, were associated with increased public transport usage and reduced car ownership. Loo et al. (2017) investigated the influence of safety and security in passenger satisfaction and loyalty in the air travel sector. Hensher and Stanley (2020) suggested that high service quality in public transport is positively associated with increased passenger satisfaction and loyalty. Li et al. (2021) explored the impact of service quality and customer satisfaction on passenger loyalty in public transport systems, focusing on the case of Chongqing, China. The results of the study show that reliability, comfort, safety, and customer service are the significant predictors of passenger loyalty. Dragana Grujić et al. (2013) used Importance-Performance Analysis (IPA) with the aim of identifying the key elements of service quality that require improvement in public transportation. The results of the study show that, elements that are the most important from user and non-users' point of view are elements that belong to the set of tangibles. The study concludes that, cleanliness in the vehicle and ventilation in the vehicle will increase the level of users' satisfaction and impression of the improvement of the public transport system quality. Randheer K. et al. (2011) used SERVQUAL in Public Transportation to investigate commuters' perceptions of service quality. The preexisting component was expanded to include culture. The study's findings demonstrated the significance of culture in gauging the context of service excellence. According to a comparison of the means of the SERVQUAL components, commuters are most influenced by responsiveness, assurance, reliability, culture, and empathy. Laura Eboli and Gabriella Mazzulla (2008), used a stated preference experiment to investigate the quality of service in public transportation. The study's findings indicate that the most crucial factor that passengers take into account when choosing public transportation is service frequency. Another crucial component of service excellence is fare. Yaya et al. (2015) investigated the demographic parameters that may affect customers' perceptions of service quality and created a scale to assess customers' perceptions of service quality in public transportation. When evaluating customer perceived quality in a public transportation scenario, the three categories of functional, convenience, and physical environment quality were validated as underlying determinants. The study's findings indicate that while education was inversely correlated with perceived quality, age and having a driver's license are directly and favorably correlated with service quality. Aniebiet et al. (2021) studied public transportation firms' customer loyalty and service quality. The study's goal was to ascertain how public transportation firms' customers' loyalty was impacted by factors such as journey duration, driver skill, passenger comfort, safety, and cleanliness of vehicle. The study's conclusions showed that while travel time had no discernible impact on passengers' loyalty to public transportation companies, passenger safety, comfort, driver skill, and vehicle cleanliness all significantly increased customer loyalty.

Service Quality in Metro Rail Transportation

According to a study by ANH Ibrahim et al. (2022) user perceptions of satisfaction with the service provided by Malaysia's urban rail transport system were primarily influenced by three service quality factors namely facilities, information signs, and information availability. According to this study, one of the key elements influencing users' perceived satisfaction with the Klang Valley's LRT services was employee performance. Yuning Wang et al. (2020) evaluated the significant effects of customer satisfaction and service quality on the desire of Chinese rail transport users to reuse. The empirical study's findings supported the notion that there are several ways to define service quality, including functional, technical, comfort, cleanliness, planning, and dependability. Additionally, it increases customer happiness, which in turn influences passengers' intention to buy. This has a beneficial impact on reuse intention. Saw Y Q et al. (2020) looked into how satisfied London's Tyne and Wear Metro passengers were. The study's findings indicate that the key service quality characteristics

that have a major impact on customer satisfaction are infrastructure quality, ticket buying facilities, security, safety, and comfort. Juan de Oña et al. (2020) points out that, service quality has a direct and an indirect effect on behavioural intentions (through satisfaction), in the case of LRT systems. According to the researchers, service quality is an important predictor of behavioural intentions. De Oña et al. (2015) studied the relationship between perceived service quality, customer satisfaction and behavioral intentions for the Metro of Seville in Spain. Users' perceptions of service quality were measured along eight dimensions such as tangible service equipment, accessibility, service availability, information, security, customer service, personal space, and environmental pollution. Priyanka et al. (2023) studied service quality of Chennai Metro. The findings indicate that atmosphere, coach conditioning, cleanliness, station access, hospitality, administration service, and station facilities etc. have significant impact on customer satisfaction. Yogendra Pal Bharadwaj and Mukesh Singh (2020) studied the effect of service quality on commuters' satisfaction towards the adoption of Metro Services in Delhi. The findings showed that commuter friendliness is the primary element influencing commuter satisfaction, followed by assurance, dependability, safety and security considerations. Anjali Sharma (2013) added security as a new dimension in the existing dimensions of SERVQUAL model and it has been found that, security significantly influences customer satisfaction

Statement of the Problem

The SERVQUAL model is a sufficient tool to measure service quality from customers' perspective (Mikhaylov et al., 2015). Service quality gap analysis studies are crucial for businesses aiming to understand and improve the quality of their services. These studies typically involve comparing customer expectations with their actual perceptions of the service received, identifying any gaps that may exist between the two. Therefore, research aimed at measuring the perception of commuters regarding service quality rendered by the public transport services will be beneficial to consumers and service producers. But there aren't any research studies which discusses service quality gap based on SERVQUAL model in Metro Rail Transportation from Indian context. Hence the present research study focused on the following objective, to measure and assess the level and significance of service quality perception of the commuters on SERVQUAL scale given by Parasuraman et al. (1988). This research study also aims to study the influence of age on expectation and perception of passengers regarding service quality of Kochi Metro Rail.

Objectives of the Study

1. To identify the important factors determining service quality of Kochi Metro rail transportation system that leads to customer satisfaction.
2. To find out the gap between expected service quality and perceived service quality of commuters by using SERVQUAL instrument.
3. To study the influence of age on expectation and perception of passengers regarding service quality of Kochi Metro Rail.

Research Questions

1. What is the service quality of Kochi Metro according to the expectation and perception of Passengers?
2. What is the influence of age of passengers on Service Quality Dimensions of Kochi Metro Rail?

Hypotheses

- H₀1: There is no significant difference between passengers' expectation and perception on service quality offered by Kochi metro rail.
- H₀2: There is no significant difference in passengers' expectations on the tangibility and assurance service quality dimensions across different age groups.
- H₀3: There is no significant difference in passengers' expectations on the reliability, responsiveness, and empathy service quality dimensions across different age groups.
- H₀4: Passengers perceived service quality is not significantly different across the different age groups regarding five service quality dimensions.

Methodology

Participants and Procedure

This research study was designed as descriptive and analytical in nature based on secondary and primary data. Secondary data were collected from previous research studies, books, articles and from Kochi Metro Rail websites. Primary data were collected from the regular passengers of Kochi Metro and occasional passengers and tourists were excluded from the population. Here, on an average, more than fifty thousand passengers are

using Kochi Metro daily, and no population list was available, hence purposive sampling method was used to select the sample respondents. Researchers can ensure that the data acquired is rich and in line with the study's aim by using purposive sampling to target passengers who have experience with specific aspects of the service (Patton, 2015). Data from 384 samples were collected. The researcher travelled along with the passengers and collected data directly from the respondents.

Measurement of Variables

This study aimed to assess the potential discrepancy between passengers' expectations and the actual level of service provided by Kochi's metro train system. Service quality was determined using the SERVQUAL methodology, which applies the five aspects of service quality—tangibility, reliability, responsiveness, assurance, and empathy. There were 22 statements in the research tool. There were three parts to the structured interview schedule. Information about the respondents' age, gender, occupation, employment status, and income were requested in the first part. The respondents' expectations for service quality in relation to the various commuter services were evaluated in the second section, and their opinions of the service quality that the service operator really offered were gauged in the third. Using a five-point Likert-type scale with strongly disagree (1) and strongly agree (5) as anchors, the respondents' degree of agreement with the expectations and perceptions statements was measured.

Data Analysis

We analysed the data collected from respondents with IBM SPSS 20. version software. Descriptive statistics, Gap Analysis, Paired sample t test, Tukey HSD test, Pillai's Trace test, Wilks' Lambda test etc. were used to test the given hypothesis. Cochran's Sampling calculation formula was used to decide the appropriate sample size for unknown population.

$$n_0 = z^2 pq / e^2$$

p = 0.5 and hence q = 1-0.5 = 0.5; e = 0.05; z = 1.96

$$= ((1.96)^2 (0.5(1-0.5)) / (0.05)^2 = 384.$$

Table:1-Demographic Profile of Respondents

Categories	Frequency	Percentage
Gender		
Male	213	55.5
Female	171	44.5
Age		
Below 20 years	39	10.
20-40 years	130	34
40-60 years	150	39
Above 60 years	65	17
Education		
Professionals	81	21.
Post -graduation	100	25.7
Graduation	139	36.3
12 th and Below	64	16.7
Occupation		
Government Employee	84	21.9
Private Employee	133	34.6
Business/ Profession	44	11.5
Categories	Frequency	Percentage
Self Employed	59	15.5
Others	64	16.7
Income		
Up to 100000	67	17.4
100001-200000	54	14.1
200001-300000	90	23.4
300001-400000	81	21.1
Above 400000	92	24.0

Source: Primary data.

The demographic profile of the study sample, consisting of 384 Kochi Metro rail passengers, is summarized in Table 1. 55.5% of the respondents identifying as male and 44.5% as female. In terms of age, the majority of respondents fall within the 40-60 years category (39%), followed by those aged 20-40 years (34%), and a smaller proportion of respondents are either below 20 years (10%) or above 60 years (17%). Regarding education, 36.3% of respondents have completed graduate studies, 25.7% hold a post-graduate degree, 21% are professionals, and 16.7% have completed higher secondary school education or lower. In terms of occupation, the sample includes 34.6% private employees, 16.7% others, 21.9% government employees, and smaller proportions from business, self-employment etc. The income distribution indicates that 23.4% of respondents earn between ₹200,001-₹300,000 and 21.1% earn between ₹300,001-₹400,000 annually, with a significant portion (24%) earning above ₹400,000. Overall, the data provides a comprehensive demographic representation of passengers of Kochi Metro.

Table: 2- Service Quality Gap Score of Kochi Metro Services					
D	S.C	Statements Related to Expectation and Perception	E	P	G (P-E)
Tangibility	T1	Modern looking trams and stations	4.77	3.91	-0.86
	T2	Physical facilities should be visually appealing	4.73	3.90	-0.83
	T3	Tickets, instruction boards etc. (Materials) must be clear and visually appealing	4.76	3.54	-1.22
	T4	Employees should be smart in their appearance	4.67	3.77	-0.9
Reliability	R1	Services should be on time	4.87	3.97	-0.9
	R2	Must show a sincere interest in solving passengers' problems	4.83	3.53	-1.3
	R3	Should provide the timely services	4.80	3.63	-1.17
	R4	Maintain an error free record	4.79	3.51	-1.28
	R5	Should follow the promise to do some services by a certain time,	4.81	3.60	-1.21
Responsiveness	Re1	Employees prompt response when the services performed	4.83	3.61	-1.22
	Re2	Employees in Kochi metro should provide prompt service	4.79	3.57	-1.22
	Re3	Employees should always willing to help you	4.79	3.50	-1.29
	Re4	Employees in Kochi metro must never too busy to respond to your request	4.81	3.24	-1.57
Assurance	A1	The behaviour of employees is creating confidence in you	4.77	3.28	-1.49
	A2	Feel safe in your transactions with Kochi metro	4.81	3.87	-0.94
	A3	Employees are consistently courteous with you	4.80	3.57	-1.23
	A4	Employees having much knowledge to answer the questions	4.81	3.22	-1.59
Empathy	E1	Giving special attention to women, children and handicapped	4.84	3.74	-1.1
	E2	Operating hours are convenient to all its customers	4.81	2.80	-2.01
	E3	Employees are giving personal attention	4.70	2.89	-1.81
	E4	Having best interest at heart	4.77	3.70	-1.07
	E5	The employees are understanding the customer's specific needs	4.75	3.47	-1.28
Source: Primary Data					

Table .2 is explaining the regular passenger's expectation and perception of Kochi metro rail services. The expectation and perception score denote the mean opinion of passengers and the expectation score indicates that majority of the passengers having higher expectation regarding the services of Kochi Metro rail. While looking into the opinion of passengers regarding the perceived service quality, it could be seen that their perception has not been attain the range of their expectation. While looking into each dimension of SERVQUAL model, it could be seen that, highest gap score (-1.22) identified in related to clear and visually appealing of tickets, instruction board like material aspects of Kochi metro rail, because of passengers having higher expectation level regarding the same. Regarding the reliability factors, passengers having higher expectations about sincere interest of Kochi Metro rail in solving their problems (-1.3), error free record maintenance (1.28) and following the promises made by the metro in related to certain services at specified time (-1.21). The gap score related to third dimension, it could be seen that passengers having higher perception regarding prompt response (-1.22), providing prompt services (-1.22), employees willingness to help (-1.29), and prompt response about the passenger's request without any delay or busy (-1.57). Regarding assurance, it was found that passengers having

higher expectation regarding the behaviour of employees (-1.49), employees courteous (-1.23), and employees' knowledge regarding the questions raised by passengers (-1.59). Regarding the last dimension, it was found that passengers having higher expectation about convenient operating hours of metro rail (-2.01), employees' capability of understanding passengers' specific needs (-1.28) and employees special attention attitude towards the passengers (-1.81). While in the case of total gap score and average gap score of five dimensions, it could be seen that Empathy having higher gap score and average.

Table: 3. Average SERVQUAL Score of all Five Service Quality Dimensions			
Sl. No	Dimensions	Total Score	Average Score
1	Tangibility	-3.81	-0.9525
2	Reliability	-5.86	-1.172
3	Responsiveness	-5.3	-1.325
4	Assurance	-5.25	-1.3125
5	Empathy	-7.27	-1.454
Total			-6.216
Average SERVQUAL Score			-1.2432
Source: Primary Data			

Table 3. shows the average gap score. The gap score itself explained that majority of the regular passengers having higher expectation regarding empathy and secondly the higher gap score goes to reliability and then responsiveness and assurance. This research article was further analyzed the statistically significant difference between passengers' expectations and their actual perception based on their experience. Paired sample t-test was is providing a valuable output regarding the significant difference.

Dimension		Paired Differences					T	P-Value
		Mean	SD	SEM	95% Confidence Interval			
					Lower	Upper		
Tangibility	Pair 1	.864	1.055	.054	.758	.970	16.036	.000
	Pair 2	.830	.929	.047	.737	.924	17.483	.000
	Pair 3	1.214	1.220	.062	1.092	1.337	19.478	.000
	Pair 4	.901	.998	.051	.801	1.001	17.670	.000
Reliability	Pair 5	.898	.911	.047	.807	.990	19.295	.000
	Pair 6	1.292	.934	.048	1.199	1.386	27.080	.000
	Pair 7	1.167	.975	.050	1.069	1.265	23.421	.000
	Pair 8	1.277	1.037	.053	1.173	1.381	24.099	.000
	Pair 9	1.209	.931	.048	1.115	1.302	25.404	.000
Responsiveness	Pair 10	1.211	.918	.047	1.119	1.304	25.829	.000
	Pair 11	1.217	.939	.048	1.122	1.311	25.351	.000
	Pair 12	1.292	1.168	.060	1.175	1.410	21.653	.000
	Pair 13	1.567	1.224	.063	1.444	1.690	25.053	.000
Assurance	Pair 14	1.511	1.399	.072	1.369	1.653	20.938	.000
	Pair 15	.932	.878	.045	.844	1.020	20.785	.000
	Pair 16	1.230	.992	.051	1.130	1.329	24.265	.000
	Pair 17	1.592	1.451	.074	1.446	1.738	21.437	.000
Empathy	Pair 18	1.097	1.053	.054	.991	1.202	20.384	.000
	Pair 19	2.010	1.585	.081	1.851	2.170	24.820	.000
	Pair 20	1.815	1.688	.086	1.645	1.984	21.044	.000
	Pair 21	1.063	1.006	.051	.962	1.164	20.675	.000
	Pair 22	1.280	1.131	.058	1.166	1.394	22.129	.000
Source: Primary Data								

Table 4. shows that, in the case of all pairs under 5 dimensions, indicates that all passenger's expectation is significantly different from their actual perception about the services provided by the Kochi Metro rails, because of all the pairs having p-value is lesser at 5 per cent significant level. Hence, it can be inferred that there is a significant difference existing between passengers' expectation and perceived quality of services provide by Kochi Metro. Further, the study was processed the Multivariate test to find out the age wise difference in passengers' expectation and their perception regarding the services provided by Kochi Metro rail.

Table 5: Influence of Age on Passengers Expectation on Service Quality of Kochi Metro Rail							
G	Dimensions	Effect	Value	F	Hypothesis df	Error df	Sig.
Age	Tangibility	Pillai's Trace	.129	4.250	12.000	1134.000	.000
	Reliability	Wilks' Lambda	.977	.572	15.000	1035.611	.898
	Responsiveness	Wilks' Lambda	.957	1.400	12.000	995.094	.159
	Assurance	Pillai's Trace	.066	2.111	12.000	1122.000	.014
	Empathy	Pillai's Trace	.065	.671	15.000	1131.000	.061
	Tangibility	Box's M=464.489, $F_{(10, 108772.752)} = 45.586, p=.000<0.05,$					
	Reliability	Box's M=28.497, $F_{(20, 87634.764)} = .671, p=.075<0.05$					
	Responsiveness	Box's M=45.643, $F_{(20, 88219.154)} = .528, p=.673<0.05$					
	Assurance-Empathy	Box's M=663.458, $F_{(10, 10929.310)} = 65.112, p=.000<0.05$ Box's M=275.885, $F_{(15, 95785.787)} = 17.968, p=.000<0.05$					
Error variance of the dependent variable is not equal across groups							
G=Group, Design: Intercept + Age							

Table 5. shows the influence of age on passengers' expectation on service quality. Regarding the covariance metrics of groups, it could be seen that covariance metrics of the depended variables are not equal across the different age group (Box's M plot test) in related to tangibility and assurance, hence Pillai's Trace test was used to interpret the result of multivariate analysis for ensuring the power of result, while in the case of reliability, responsiveness and empathy, it could be seen that covariance metrics of the depended variables are equal across the different age groups, hence Wilks' Lambda ($\wedge$) test was used to interpret the test result. The result indicates that passenger's expectation regarding the service quality of Kochi Metro rail is significantly different across the different age groups regarding tangibility dimension and assurance dimensions, while in the case of other three dimensions, the result was proven that all the age groups have same expectation level regarding reliability, responsiveness, and empathy dimensions. Hence, further test between subject effect and Tucky HSD test was processed with tangibility and assurance to find out which of the statements having statistical significance and which of the group is significantly different from each other regarding the statements.

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Tangibility	Employees should be smart in their appearance	4.918	3	1.639	3.571	.014
		(I) Age	(J) Age	MD (I-J)	Std. Error	
		20-40 years	40- 60 years	.23*	.084	
Assurance	The behaviour of employees in Kochi metro should instill confidence in you	4.349	3	.116	.269	
		(I) Age	(J) Age	MD (I-J)	Std. Error	
		below 20 years	above 60 years	.45	.023	.000

Result indicates that passenger's expectation was significantly different across the different age groups regarding employee's smartness in their appearance (Tangibility) and behaviour of employees (Assurance). In the case of employee's smartness, 20-40 years age passengers' expectation was significantly different from 40-60 years age groups and 20-40 years age groups having higher expectation than the other group (.23). In the case of employee's behaviour below 20 years age group passengers' expectation was significantly higher than the above 60 years age group passengers.

Table 6: Influence of Age on Passengers Perception on Service Quality of Kochi Metro Rail							
G	Dimensions	Effect	Value	F	Hypothesis df	Error df	Sig.
Age	Tangibility	Pillai's Trace	.092	2.974	12.000	1134.000	.000
	Reliability	Pillai's Trace	.115	2.993	15.000	1131.000	.000
	Responsiveness	Pillai's Trace	.098	3.194	12.000	1134.000	.000
	Assurance	Pillai's Trace	.127	4.118	12.000	1122.000	.000
	Empathy	Pillai's Trace	.180	4.811	15.000	1128.000	.000
	Tangibility	Box's M=130.350, F _(30, 8336.546) =6.183, p=.000<0.05					
	Reliability	Box's M=138.280, F _(20, 9012.956) =4.312, p=.000<0.05					
	Responsiveness	Box's M=102.702, F _(20, 9012.956) =4.871, p=.000<0.05					
Assurance	Box's M= 50.384, F _(20, 9033.758) = 2.390, p=.000<0.05						
Empathy	Box's M=158.892, F _(30, 8337.702) =4.954, p=.000<0.05						
Error variance of the dependent variable is not equal across groups							
G=Group, Design: Intercept + Age							

Table 6. is explaining the passenger's perception regarding the quality of services provided by Kochi Metro rail. The covariance metrics of the depended variables are not equal across the different age group (Box's M plot test) in related to all the dimensions, hence here again Pillai's Trace test was used to interpret the test result. The Multivariate test result indicates that passenger's perception is significantly different across the different age groups, hence test between subject effect and Tucky HSD test was processed.

Regarding further test result, it could be seen that one statements from each dimension were showing statistical significance regarding the passenger's perception on different age groups.

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Tangibility	Tickets, instruction boards etc. (Materials) must be clear and visually appealing	10.813	3	3.604	3.670	.012
		(I) Age	(J) Age	MD (I-J)	Std. Error	Sig.
		Below 20 years	40- 60 years	.71*	.252	.025
Reliability	Should follow the promise to do some services by a certain time	14.700	3	4.900	7.771	.000
		(I) Age	(J) Age	MD (I-J)	Std. Error	Sig.
		20-40 years	40- 60 years	.29*	.099	.022
Responsiveness	Employees in Kochi metro should provide prompt service	12.631	3	4.210	6.457	.000
		(I) Age	(J) Age	MD (I-J)	Std. Error	Sig.
		Below 20 years	40- 60 years	.77*	.205	.001
Assurance	The behaviour of employees is creating confidence in you	38.372	3	12.791	8.610	.000
		(I) Age	(J) Age	MD (I-J)	Std. Error	Sig.
		20-40 years	40- 60 years	.61*	.153	.000
Empathy	Giving special attention to women, children and handicapped	18.942	3	6.314	7.180	.000
		(I) Age	(J) Age	MD (I-J)	Std. Error	Sig.
		Below 20 years	Above 60 years	1.86*	.516	.002

Test result indicates that below 20 years age groups having significantly higher perception (.71) than the 40-60 years age groups passengers regarding clear and visual appearance of tickets, instruction board. Regarding the reliability, 20-40 years age groups having significantly higher perception (.29) than 40-60 years age groups. While in the case of responsiveness, below 20 years age groups having significantly higher perception (.77) than 40-60 years age groups. In the case of assurance, 20-40 years age group respondents' perception (.23) is significantly higher than 40-60 years age groups and finally the dimension empathy, it was found that below 20 years age groups perception (1.86) is significantly higher than above 60 years age groups.

Result of Hypotheses

The first research question was raised at the study initial stage was whether the passengers' expectations and perceptions are different regarding the services quality of Kochi metro or not. Based on this, study has formulated the first hypothesis that

H₀₁: There is no significant difference between passengers' expectation and perception on service quality offered by Kochi metro rail project.

Based on the paired sample t-test, it was found that the null hypothesis (H₀₁) stands rejected and found that all passenger's expectation is significantly different from their actual perception about the services provided by the Kochi Metro rails, because of all the pairs having p-value is lesser at 5 per cent significant level. The results show that, passenger's expectation is significantly higher than the actual perceived service quality of Kochi Metro Rail project with all five dimensions.

Secondly, study was gone for finding what are the expectations and perceptions of different age group passengers regarding the service quality of Kochi metro rail. While go through the review of prior studies, it was found that many authors were explained that age is an important factor which decide the perception of people and their expectation. Age is one of the determinants, that allow marketer to determine the changes in service quality and product quality, because of age is significantly influencing the service quality (Thompson and Kaminski, 1993). Some of the studies were found an irrational relationship between age and service used (Hansman and Schutjens, 1993). Age of people, their morality, perceptions, thinking process, etc., are very different, hence age is considered as an important element which drive different expectation and perception (Webster, 1989). Based on these observations, study has been formulated age related hypotheses i.e.,

H₀₂: There is no significant difference in passengers' expectations on the tangibility and assurance service quality dimensions across different age groups.

H₀₃: There is no significant difference in passengers' expectations on the reliability, responsiveness, and empathy service quality dimensions across different age groups.

H₀₄: Passengers perceived service quality is not significantly different across the different age groups regarding five service quality dimensions.

The result of hypotheses explains that passenger's expectation on service quality of Kochi metro rail is significantly different across the age groups regarding tangibility and assurance service quality dimension ($p < 0.05$). Hence null hypothesis (H₀₂) is rejected. While no significant difference found on reliability, responsiveness and empathy service quality dimensions ($p > 0.05$). Hence null hypothesis (H₀₃) is not rejected. Which means that, age influences expectations about Tangibility and Assurance, but not about Reliability, Responsiveness, or Empathy for Kochi Metro Rail passengers. On the other hand, it was found that passenger's perception on service quality of Kochi Metro is significantly different across the age groups in related to all five-service quality dimension with a p-value of 0.000 for each ($p < 0.05$). Hence null hypothesis (H₀₄) is rejected. Which means that, age significantly affects passengers' perceptions of service quality in terms of Tangibility, Reliability, Responsiveness, Assurance, and Empathy for Kochi Metro Rail Transportation System.

Summary of Findings, Conclusion and Recommendation

Study result found that majority of the regular passengers having higher expectation regarding the service quality of the Kochi metro, but unfortunately perceived service quality was not much satisfactory based on passengers' opinion when compared to their expectation level. As said earlier, passenger is an important element of the successful drive of Kochi Metro, hence improving service quality as per the expectation of passenger is unavoidable. Results of the study show that, in the case of total gap score and average gap score of five dimensions, it could be seen that empathy having higher gap score (-7.27) and average (-1.454) followed by reliability (-5.86) and responsiveness (-5.3). Study also found that, majority of the passengers were not satisfied with the operating hours of Kochi Metro (-2.01) and employees' attitude regarding the special attention to the passengers (-1.81). Results of the study also show that, passenger's expectation on service quality of Kochi metro rail is significantly different across the age groups regarding tangibility and assurance service quality dimension while no significant difference found on reliability, responsiveness and empathy service quality dimensions. While age significantly affects passengers' perceptions of service quality in terms of Tangibility, Reliability, Responsiveness, Assurance, and Empathy for Kochi Metro Rail. The service quality gap analysis shows that, Kochi Metro needs to take care of following points i.e.,

1. Increase the quality of material like tickets, boards etc., and ensure the visual appearance quality.
2. Ensure ventilation systems are functioning properly in enclosed stations to improve comfort.

3. Improve the clarity of signage in stations, with better route maps, up-to-date schedules, and information about delays or disruptions. Consider multilingual signage to accommodate diverse populations.
4. Add more frequent services during peak hours to minimize crowding and reduce the impact of occasional delays.
5. Regularly review and adjust timetables based on real-time data, feedback, and seasonal changes (e.g., holidays or festivals) to ensure that the schedules are as realistic as possible.
6. During peak commuting hours, ensure that additional staff members are available to assist passengers with inquiries, directions, or issues.
7. For routine questions like ticketing or schedule information, provide self-service kiosks at stations, reducing the dependency on staff and improving response time.
8. Provide training for staff on safety protocols, including emergency procedures, conflict resolution, and customer service during stressful situations.
9. Must show more sincere interest in solving passengers' problems
10. Regularly publish performance reports regarding on-time service, maintenance, and safety records to demonstrate the system's reliability to the public.
11. Maintain an error free record.
12. Ensuring the prompt response as per the request and queries of passengers
13. Take care of employee's behaviour and periodic training to them for improvising their attitude, behaviour and performance
14. Provide better knowledge practice among employees and train them to stick on courteous to passengers
15. To fix more convenient operating hours in Kochi Metro after conducting a preliminary investigation among regular and occasional passengers
16. Provide training programmes for employees for handling the passengers in an effective way
17. Provide a chance to the Kochi Metro employees to interact with other metro employees regarding the passenger management.
18. Ensure that priority seating for the elderly, disabled, and pregnant passengers is clearly marked and actively enforced. Conduct awareness campaigns to encourage other passengers to respect priority seating areas.
19. Use mobile apps to provide personalized travel information, such as updates on the fastest routes, potential delays, or tips for avoiding crowded trains during busy times.
20. After implementing changes, it's essential to continuously monitor customer satisfaction and gap scores. This can be done through regular surveys (to track how perceptions change over time) and passenger feedback mechanisms (e.g., suggestion boxes, mobile apps)
21. Most importantly, consider the age difference while preparing development planning in Kochi Metro, because of age is significantly influencing the passenger's perception.

Limitations and Future Scope for Research

This study has certain limitations. Firstly, this is a cross-sectional study. Longitudinal studies may give more clear evidence regarding the service quality of Kochi Metro. Other demographic variables like gender, education etc. can also be taken in to consideration to check its influence on service quality gap. The study used purposive sampling method for data collection. To ensure that the data gathered is comprehensive and in line with the study's objectives, researchers can use purposive sampling to target passengers who have firsthand experience with key aspects of the service. However, because purposive sampling is not statistically representative of the overall population, it may introduce bias into the sampling process and limit the generalizability of the results.

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Factors Influencing Behavioural Intention of Working Women to adopt Social Media Platforms for Fashion Items Purchase in Delhi-NCR

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Abstract

Today, social media has become prevalent in all fields. Social media can be an effective marketing tool for businesses, offering a wide range of possibilities and benefits to both customers and organizations. Social media usage and popularity have increased, and as a result, it has become an essential component of modern marketing strategy. Social media marketing helps both businesses and consumers. This study investigates the factors influencing behavioural intention of working women to adopt social media platforms for fashion items purchase. The conceptual model was proposed based on six factors - four factors (Performance expectancy, Social Influence, Facilitating conditions and Hedonic motivation) of UTAUT2 (Unified theory of Acceptance and Use of Technology) and one factor (Attitude) from TPB (Theory of Planned Behaviour) and one factor (Trust) from literature. The questionnaire was used to collect data from 394 working women of Delhi-NCR. The Key findings from structural equation modelling (SEM) provided strong evidence for the validity of the current model and the positive impact of performance expectancy, social influence, Trust, and attitude on the behavioural intentions of working women for fashion items. Facilitating conditions and Hedonic motivation were determined to be insignificant. Hopefully, this study will offer a variety of theoretical and managerial implications and suggestions on how social media marketers can efficiently execute their strategy.

Keywords- Social Media Marketing, Social Media Platforms, Working Women, Behavioural Intention, Fashion Items.

Introduction

Businesses and consumers worldwide can now leverage cutting-edge social media solutions (hardware and software) to interact with customers more effectively, create and distribute enough content, and enhance interoperability (Berthon et al., 2012). The use of social media marketing by consumers to satisfy their needs is also growing. The term "social media marketing" describes the use of social media platforms to market goods, services, or brands and interact with consumers. Due to the increasing adoption and use of social media platforms like Facebook, Instagram, Twitter, LinkedIn, TikTok, and others, it has evolved into a crucial part of contemporary marketing strategy. In marketing literature, women are typically thought to have a more positive attitude toward shopping than men, who are more focused on the practical implications of their purchases (Dittmar et al., 2004). Shopping and fashion consumption have always been associated with women. Compared to men, women typically have greater knowledge and interest in clothing (Bakewell et al., 2006). Another study depicted women purchase new clothing and influence others to do the same, 80 percent of consumer purchases are influenced by women, who purchase more things than males (Cho & Workman, 2011). This study focuses on the behavioural intention of working women for fashion items on social media platforms. Women who are actively employed outside as well as they have obligations inside the home or family are referred to as "working women." These women work in a variety of fields and professions and contribute to the economy and society through their skills and labour. The analysis of fashion item, an aspect of tremendous relevance in the lives of working women, is central to the emphasis of this study. Professionalism necessitates not only skill but also a polished appearance. In this scenario, fashion item is not just a luxury but also a necessary requirement. The goal of this study is to investigate the complex world of working women's behavioural intention on social media platforms, especially in relation to fashion items.

Literature Review

Social Media (SM)

There are many different types of social media, such as Facebook, Twitter, and weblogs. Users of social media can interact with people who share their interests. Social media is utilised differently by various clients and businesses. It does not even try to take the place of transactions or even conversation by phone or email. Rather, it aims to enhance the value of each encounter or compliment them either the current or potential customer (Andzulis et al., 2012).

Social Media Marketing (SMM)

Social media marketing makes use of social media platforms to raise a business or online presence for the aim of showcasing its goods and services. Social media platforms are useful for building social networks and exchanging ideas and information. Social media marketing is having a big impact on how businesses sell themselves. In some businesses, this sort of marketing is progressively gaining ground, developing, and replacing more traditional strategies. Dwivedi et al. (2021) discussed Some specialized issues like artificial intelligence, marketing using augmented reality, digital content management, mobile marketing, and advertising, B2B marketing, electronic word of mouth, and related ethical concerns. The findings of this study were that studies have neglected to develop a deeper level of quantitative and qualitative focused research on the negative aspects of social media. it also discussed the need for a rebalancing of research emphasis on aspects of digital and social media marketing. Alalwan A. A. et al. (2017) aimed to systematically examine and review the current studies that have conducted over the related area of social media and marketing. In this study, 144 articles were reviewed and with the help of articles role of social media on advertising, the electronic word of mouth, customers' relationship management, and firms' brands and performance were considered. It has been found that some researchers also studied the impact of social media on consumer's attitude and their buying behaviour and the main theme looked at how social media applications could help with marketing and advertising initiatives.

Working Women's Buying Behaviour On Social Media Platforms

Women who work in a variety of professions, including but not limited to those of doctors, teachers, engineers, lawyers, scientists, business professionals, artists, and labourers, are working women. They might work in a variety of fields, including healthcare, education, technology, finance, manufacturing, and services. Historically, women have been seen as a driving force behind revolutions due to their high position in many countries and their capacity to pursue intellectual and spiritual pursuits (Evans et al., 2001). Home management is a shared role between men and women. When deciding whether to work outside the home, women must be allowed to do so without interference, and if they do, there must be no discrimination. Instead, they ought to be honoured for their financial and social security contributions to the household (Hoffman & Holmes, 1976). Guha (2013) aimed to document the evolving patterns of female consumer behaviour in urban India. The paper's main goal was to determine how working women's perceptions and purchasing patterns have changed in comparison to those of non-working women in urban India. The findings suggested that working women were more likely to participate in the purchasing process. Compared to non-working married women, they were more price aware. Additionally, research showed that working women were more brand loyal than married women who do not work. Working women were more concerned about quality than married women who do not work. However, unmarried women who do not work valued quality.

Arulalan & Fields (2021) intended to study at the apparel impulse purchases made by working women in New Zealand. Age, emotional state, store environment, sales, and promotions are the key variables considered that were related to and may influence impulsive clothes purchases. According to the findings, impulse buying occurs across all age groups, however young New Zealand working women between the ages of 20 and 35 exhibited more of these behaviours than women beyond the age of 35. A part of working women's impulse buying behaviour was influenced by the store environment, including window and in-store displays. Emotional state had an impact on clothes purchase decisions. Sales and promotions were found to be the main factor of impulsive buying. Tewary et al. (2021) discussed the attitudes and actions of young working women towards organic cosmetic goods, including knowledge, opinions about their safety and efficacy, and readiness to spend more for organic cosmetics. Attitude, Environmental consciousness, Health consciousness, Price consciousness, Availability, and Brand were the main variables of the study. The study's findings show a substantial correlation between environmental and health consciousness and young working women's attitudes towards buying organic cosmetics. It was found that customer attitudes toward or intentions to purchase organic cosmetic goods were influenced by factors such as availability, health, brand, and price consciousness, as well as environmental and health consciousness. Balaji et al. (2021) examined how working women in India's National Capital Region choose personal care goods. Preferred place for Purchase, reasons for purchase, Product quality, innovation of the product, and brand perception were the main variables. The study's major findings suggested that working women's purchase decisions were influenced by the product's brand based on their age. In contrast, the income of working women had no impact on the study's analysis of the buying criteria. Most working women, according to the survey's findings, chose to buy personal care products to improve their personalities and physical well-being.

Fashion Items Shopping On Social Media Platforms

One of the sectors with the fastest global growth is apparel. Working women have become a significant portion of the clothes purchasing market. Women are really giving priority to clothing, causing a change in purchasing habits of women. Typically, women spend more money on fashion out of desire rather than necessity or utility

(Cho & Workman, 2011). Comparatively speaking, it is simpler to find high design clothing at reasonable prices for women. Women are known to find shopping to be enjoyable, gratifying, hedonistic, and pleasurable. The significance of women's shopping experiences and the ongoing need for clothing that results from them provide this sector with significant growth potential. Women are typically more interested in purchasing items connected to self-expression that would enhance their appearance, such as handbags, shoes, outfits, and gifts, etc. (Yadav et al., 2019). Nash (2018) investigated the extent to which social media (SM) platforms are impacting Generation X and Y customers' decision-making processes in the context of retail fashion. Customers' decision-making processes, Online communities, social media, and Risk were the main variables of the study. The results showed that consumers' behaviours and opinions of high-street fashion businesses were influenced by several internal and external reasons, such as, Motivations and involvement, Generational Cohorts. As per the findings, the usage of social media helped and facilitated these aspects.

Parker & Kuo (2022) aimed to determine Generation Y's unique interaction with and perception of fashion m-commerce apps. E-WOM, Interaction and Purchase intention were the main variables of the study. Major Findings were, such as, M-commerce's convenience was the greatest motivator for generation-y retail engagement; Expensive items (e.g., luxury garments) represented a demotivating factor for engagement because of lower levels of trust in the smartphone retail platform; Interpersonal social media and E-WOM encouraged generation-y's purchase intention for fashion items. Ladhari et al. (2019) focused on the online shopping habits of Generation Y consumers of fashion. It had three secondary goals: To categorise Gen Y online fashion customers in accordance with their fashion lifestyle; To list their demographic and behavioural characteristics; To list the devices, they used to purchase fashionable apparel. Fashion trends, Shopping enjoyment, Economical orientation, and Brand value were the main variables. Major Findings were; Four online shopping orientations for fashion products were identified by the study: fashion trends, enjoyment of shopping, economic orientation, and brand value; Six profiles were used to group survey participants: price shoppers, fashionistas, emotional buys, discovery buyers, shopping enthusiasts, and strategic purchasers. Different sociodemographic traits and fashionable lifestyles were displayed in these profiles. According to this research, laptops were the device of choice for price and discovery consumers, with over 75% of price shoppers utilising a laptop or desktop computer for online shopping. It was discovered that emotional consumers, fashionistas, and fun shoppers were the Gen Y members most likely to utilise mobile devices for shopping.

Imtiaz et al. (2019) analysed the effects of social network marketing on female customers' intention to buy fashion goods, as well as how brand engagement and consumer motivation serve as mediators. Social network marketing, Consumer purchase intention and Consumer engagement were the main variables of this study. The study found a substantial correlation between social network marketing and consumer purchase intention. Brand engagement and consumer motivation acted as a partial mediator between social network marketing and women's fashion product purchase intentions.

Factors Affecting the Consumers' Behaviour on Social Media Platforms

Consumer's buying behaviour is affected by so many factors, we have considered some factors from Unified theory of Acceptance and Use of Technology- UTAUT2 (Performance expectancy, social influence, facilitating conditions, Hedonic motivation) (Venkatesh, Thong, & Xu, 2012) one factor from Theory of Planned Behaviour (Attitude) (Ajzen, 1991) and one factor (Trust) has been taken from literature:

Martinez & McAndrews (2023) aimed to analyze how age and gender influenced use intentions for three types of mobile payment systems. UTAUT2, a theoretical model, was tested in a quantitative investigation in the US. The study found that the intention to utilize mobile payments varies by payment type, with performance expectancy and habit serving as important determinants of behavior. Behavioural Intention was not significantly predicted by social influence, facilitating conditions and effort expectancy. Kilani et al. (2023) intended to assess the impact of UTAUT2 factors on e-wallet use in Jordan. Social influence was substituted with trust elements to gain a different perspective. The study revealed that performance expectancy, effort expectancy, habit, price value, and trust in e-wallets significantly impacted the intention to continue using them in Jordan. Facilitating conditions and hedonic motivation were the insignificant factor in this study.

Huang (2023) aimed to evaluate the factors influencing the elderly's mobile phone purchase behavior and develop a model for predicting their behaviour intention to use smartphones. The study was conducted with UTAUT2 constructs and three additional constructs- utilitarian, anxiety, trust. The study found that older persons' intention to purchase online is influenced by factors such as utilitarian, anxiety, trust, performance expectancy, effort expectancy, social influence, facilitating conditions, and habits. Hedonic motivation and Price value did not have significant impact on the elderly's mobile phone purchase behavior. Abou Ali et al. (2021) intended to study at the country-of-origin effect, trust, perceived value, and influencer marketing on consumers' desire to buy clothes through social commerce as factors influencing purchase intention. According to the

findings, three important factors that predicted customers' purchase intentions in the setting of social commerce were country of origin, trust, and perceived value.

Penney et al. (2021) intended to extend the unified theory of technology adoption and usage to include "perceived risk" and "trust". The study found that performance expectancy, effort expectancy, social influence, habit, price value, perceived risk, and trust significantly impact users' Behaviour Intention. However, facilitating conditions and hedonic motivation had no significant impact on users' Behaviour intention. Sankaran & Chakraborty (2021) intended to investigate the factors that influence Indian customers' use of mobile banking services. The study used the UTAUT2 model, which includes Social Value, Monetary Value, Emotional Value, Quality Value, Trust, and the moderating impact of gender. Effort expectancy, monetary value, emotional value, quality value, and trust all had a significant effect on behavioural intention, whereas performance expectancy and social value did not have significant effect.

Hungilo & Setyohadi (2020) attempted to explore the variables that influence Tanzanians to purchase products and services online. The study broadened UTAUT2 model through the addition of personal innovativeness, perceived risk, and trust. The study found that Effort expectancy, Price value, and Trust all had significant effects on online purchasing intentions. Performance expectancy, Social influence, Hedonic motivation, habit, personal innovativeness and perceived risk had insignificant effect on online purchasing intentions of Tanzanian consumers. Maulidina et al. (2020) intended to investigate the factors that impact people in adopting Shopee's e-commerce. UTAUT2 model was used in this study with two additional constructs, Trust and Perceived transaction risk. The findings revealed that habit and trust had a significant impact on behavioural intention. Hedonic Motivation, Effort Expectancy, Facilitating Conditions, Performance Expectancy, Social Influence, Price Value, and Perceived Transaction Risk, had no significant impact on Behavioural Intention to use Shopee.

Chresentia & Suharto (2020) stated the purpose of this study was to investigate the characteristics that impact customers' acceptance of OVO (e-wallet app) as a payment mechanism in Tokopedia (e-commerce company), particularly among persons of working age who live in Indonesia. Performance expectancy, Effort expectancy, Social Influence, Facilitating conditions, Hedonic motivation, Price value, Habit and Trust were the main variables of this study. According to the findings, performance expectancy, effort expectancy, price value, habit, and trust all have a significant impact on behavioral intention. Social influence, Facilitating conditions and Hedonic motivation had an insignificant impact on the behavioural intention.

Merhi et al. (2019) investigated the essential factors that could either help the cross-cultural adoption of mobile banking services. By adding three new constructs- trust, security, and privacy to the UTAUT2, a conceptual framework was created. According to the findings, both Lebanese and English customers' behavioural intentions to accept mobile banking services were influenced by habit, perceived security, perceived privacy, and trust. Furthermore, price value was significant in England but not in Lebanon, and performance expectancy was significant in Lebanon but not in England. Hedonic Motivations and Social Influence were insignificant for both Lebanese and English customers. Widodo et al. (2019) aimed to identify the factors influencing users's adoption of digital wallets in Indonesia. UTAUT2 model was used with two additional constructs 'Perceived risk' and 'Trust'. Performance expectancy, trust, habit, and facilitating conditions all had significant effects on Indonesians' behavioural intention to use digital wallets. The behavioural intention to adopt a digital wallet is not significantly influenced by effort expectancy, social influence, hedonic motivation, and perceived risk.

Kwateng et al. (2018) aimed to examine UTAUT2 model with age, education, user experience, and gender as moderators, factors that affect consumers to embrace and subsequently utilize m-banking services in Ghana. Trust was an additional factor to UTAUT2 in this study. According to results, habit, price value, and trust were the primary factors impacting m-banking adoption and use in Ghana. Gharaibeh & Arshad (2018) intended to investigate the factors that may influence Jordanians' intentions to use mobile banking services. The constructs of UTAUT2 (except Price value and Habit) were used in this study with two additional constructs 'mass media' and 'trust'. The findings showed that behavioural intention was positively influenced by all the constructs in the study.

Kian (2017) aimed to provide insight into the factors that may affect consumer purchase intentions on social media platforms, including perceived ease of use, perceived usefulness, social influences, trust, and perceived enjoyment. The findings of this study demonstrated that customer perceived ease of use, perceived usefulness, social influences, trust, and perceived enjoyment positively affected consumers' intentions to make purchases on social media platforms. Alalwan et al. (2017) examined the factors influencing bank customers' behavioural intentions and adoption of mobile banking. Trust was an additional factor to UTAUT2 in this study. The results primarily demonstrated that performance expectancy, effort expectancy, hedonic motivation, price value, and trust significantly and positively influenced behavioural intention. The adoption of mobile banking was also

confirmed to be significantly influenced by both behavioural intention and facilitating conditions. Social influence was found insignificant in this study.

Nadeem et al. (2017) attempted to investigate the impact of the social networking site Facebook on online apparel purchase. Role of trust was also considered in determining behavioural intention in this study. The results indicated that trust plays a good and important part in the process of using Facebook for apparel shopping. Performance expectancy, hedonic motivation, and trust all had a favourable and considerable influence on the behavior intention to use Facebook for buying. Facilitating conditions, Effort expectancy, social influence and Habit were found insignificant. Miladinovic & Hong (2016) examined the adoption of mobile shopping applications for apparel in Sweden by examining the variables that influenced users' behavioural intention to use such apps. Trust was an additional factor in the study. The findings showed that users' behavioural intention to use m-shopping fashion apps was influenced by Performance Expectancy, Habit, Facilitating Conditions, and Hedonic Motivation. In contrast, the behavioural intention to utilize m-Shopping fashion applications were not substantially influenced by Effort Expectancy, Social Influence, Price Value, or Trust. Duffett (2015) looked at how interactive social media marketing messages affect South African teens' cognitive, affective, and behavioural attitude components. The study also considers the potential effects of several other factors, such as usage and demographics, on young consumers' perceptions of SMMC. The study discovered that SMM messaging had favorable effects on cognition and attitude, and that generation Z responded most favourably to SMM messages when they were seen on mobile devices. The attitudinal components were not significantly impacted by the demographic gender variable.

Eneizan et al. (2019) examined acceptance and use of technology in a consumer environment using the unified theory of acceptance and use of technology (UTAUT). Performance expectancy, Effort expectancy, hedonic motivation, social influence, habit, facilitating conditions, Price value, Trust, and Risk were the main variables. According to the study's findings, customers' behavioural intentions about the adoption of mobile marketing were highly influenced by performance expectancy, effort expectancy, hedonic motivation, social influence, price value, facilitating conditions, habit, and risk. On the other hand, it was discovered that the trust factor was an insignificant predictor in this context.

Research Gap

There has been very little research/study on working women in India, and very little is known about this cohort's behaviour intention in the fashion items. Majority of research focused on students (Ain et al., 2016; Nikolopoulou et al., 2020; Aljaafreh, 2021), the working population has not received attention in India. According to a recent study (Dwivedi et al., 2021), working women's social media behavioural intention needs to be investigated further. As a result, this study attempts to fill this gap by presenting four factors from the Extended version of the Unified theory of acceptance and use of technology (UTAUT2)- Performance Expectancy (PE), Social Influence (SI), Facilitating Conditions (FC), and Hedonic Motivation (HM) and with two additional constructs 'Trust' from literature and 'Attitude' from Theory of Planned Behaviour (TPB) that influence working women's behavioural intention towards fashion items on social media platforms. Previous research reveals that UTAUT2 has been employed to study consumer behaviour intention to adopt mobile commerce and mobile banking (Gharaibeh et al., 2020; Kwateng et al., 2018; Slade et al., 2013; Farzin et al., 2021; Sankaran & Chakraborty, 2021; Al-Okaily et al., 2023) and online apparel purchase (Nadeem et al., 2017; Miladinovic & Hong, 2016; Abou Ali et al., 2021). The UTAUT2 theory was chosen for this study primarily because of its strong explanatory power. In present study, working women's behavioural intention for fashion items on social media platforms is studied. This study will check applicability and relative importance of all the factors/constructs in relation to build behavioural intention of working women on social media platforms. These constructs of UTAUT2 with two additional constructs 'Trust' and 'Attitude' will be studied in the present study.

Research Questions

What are the different factors influencing Behavioural intention of working women to adopt social media platforms for fashion items purchase in Delhi-NCR?

What is the impact of different factors on the Behavioural intention of working women to adopt social media platforms for fashion items purchase in Delhi-NCR?

Research Objectives

To study the different factors influencing Behavioural intention of working women to adopt social media platforms for fashion items purchase in Delhi-NCR.

To analyze the impact of different factors on the Behavioural intention of working women to adopt social media platforms for fashion items purchase in Delhi-NCR.

Hypothesis Development

UTAUT2 model was employed in several researches that were done to better understand how users adopted technology in general. This model can well explain the behaviour of people who adopt new technology. Hypotheses were developed based on existing literature and study objectives.

Performance Expectancy (PE)

The degree to which a person expects that adopting the system would enable him or her to achieve performance gains is known as performance expectancy (Venkatesh et al., 2003). Here, performance expectancy means social media platforms convenience and usefulness for working women in case of fashion items. One of the most powerful factors of behavioural intention to accept and utilize information technology (IT) has been identified as performance expectancy (Alalwan et al., 2017) (Alalwan, 2018). Thus, this study formulates the following hypothesis:

H₁: There is a significant relationship between Performance Expectancy and Behavioural Intention of working women to adopt social media platforms for fashion items.

Social Influence (SI)

The degree to which a person believes that significant individuals think he or she should employ the new method is known as social influence (Venkatesh et al., 2003). Prior research has widely shown the significance of social influence or comparable elements (i.e., reference groups, subjective norms, and opinion leaders) in increasing customer intentions (Al-Somali et al., 2009) (Martins et al., 2014). Thus, this study formulates the following hypothesis:

H₂: There is a significant relationship between Social Influence and Behavioural Intention of working women to adopt social media platforms for fashion items.

Facilitating Conditions (FC)

Facilitating conditions are defined as the degree to which a person believes a technological and organizational environment exists to facilitate system utilization (Venkatesh et al., 2003). Indeed, Venkatesh et al. (2012) hypothesized that facilitating conditions in UTAUT2 might have a direct influence on customers' intentions because facilitating conditions are not readily available to customers as in the employee context (Alalwan, 2018). Thus, this study formulates the following hypothesis:

H₃: There is a significant relationship between Facilitating Conditions and Behavioural Intention of working women to adopt social media platforms for fashion items.

Hedonic Motivation (HM)

Hedonic motivation has been shown to have a major impact on technology acceptability. It is defined as the happiness or pleasure derived from the use of technology (Brown and Venkatesh, 2005). It has been demonstrated that various characteristics, including playfulness and delight capture hedonic motivation and are strong predictors of customer acceptance of technology (Venkatesh et al., 2012) (Alalwan, 2018). Thus, this study formulates the following hypothesis:

H₄: There is a significant relationship between Hedonic Motivation and Behavioural Intention of working women to adopt social media platforms for fashion items.

Trust (TR)

Trust has a significant role in circumstances where hazards are anticipated. Shopping via mobile apps for fashion products is a recent trend and a far more recent application of technology than mobile websites and e-commerce, so users of these apps are subject to new vulnerabilities and threats (Joubert & Van Belle, 2013). Thus, this study formulates the following hypothesis:

H₅: There is a significant relationship between Trust and Behavioural Intention of working women to adopt social media platforms for fashion items.

Attitude (ATT)

Customers are more likely to have a favorable impression or draw a conclusion about products or services when they have a favorable attitude toward them, which leads to a stronger buy intention (Wu et al., 2010). Several studies investigated the connection between Gen-Y's attitudes and intention to buy fashion items. Online attitude is positively correlated with intention to make an online purchase (Loureiro & Breazeale, 2016). Thus, this study formulates the following hypothesis:

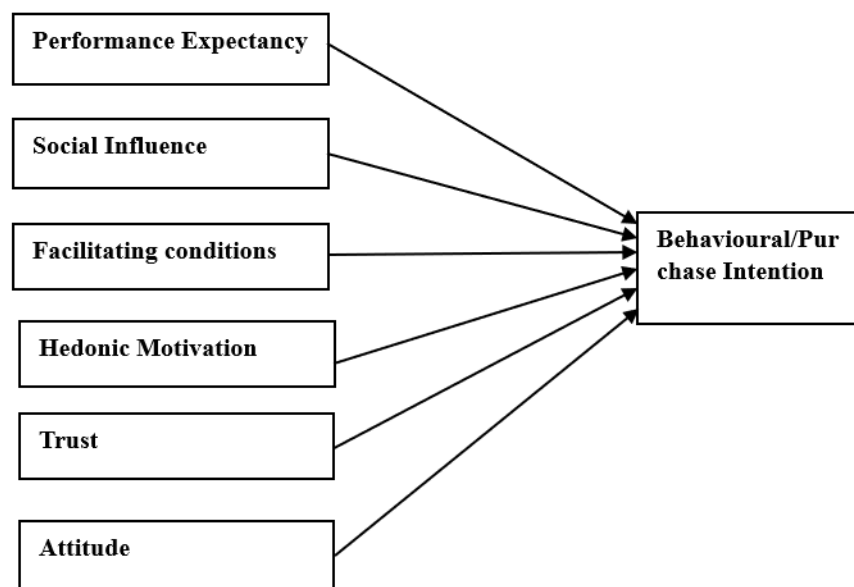
H₆: There is a significant relationship between Attitude and Behavioural Intention of working women to adopt social media platforms for fashion items.

Behavioural Intention (BIN)

The term "behavioural intention" describes a person's conscious and intentional decision or purpose to engage in a particular activity in the future. Despite not always ensuring that the intended activity will be carried out, behavioural intentions are seen as a major factor in determining actual behaviour. A prominent psychological framework termed the theory of planned behaviour (TPB) places emphasis on the significance of behavioural intention in predicting and comprehending human behaviour.

Research Model

The 4 constructs (Performance Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation) were taken from the UTAUT2 model and one factor (Attitude) from TPB (Theory of Planned Behaviour) and one factor (Trust) from literature. The independent variables in this study that were employed are Performance Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Trust, and Attitude. Behavioural intention serves as the dependent variable in this study.



(Figure 1: Proposed Conceptual Model)

Research Methodology

The current study employs a structured research technique that is mostly accomplished using questionnaires. The questionnaire was prepared with some demographic questions and some questions were framed with Likert's scale. Obtaining a reliable measurement of an underlying construct is one of the main objectives of scale development (Clark & Watson, 2016). There is no precise rule that specifies the ideal number of scale points. However, a lot of researchers agree that a five-to-seven-point scale works best for obtaining opinions. To measure the behavioural intention of working women for fashion items, 5-point Likert's scale was developed to show the degree of agreement with each statement throughout the questionnaire. The Likert scale's coding was done as follows: (1=Strongly Disagree), (2=Disagree), (3=Neither Agree nor Disagree), (4=Agree), and (5=Strongly Agree). This data collection time horizon spans from the beginning of June 2023 to the end of January 2024. As no incentive was presented to respondents, their decision to participate in the survey was motivated only by interest. Since the target population is broad and unpredictable, non-probability sampling was used. Data were collected using convenience sampling procedures. A person is considered eligible to participate in the study if they meet the inclusion criteria. They received an email including a structured questionnaire and a link to complete it. The sample frame of respondents for the study included residents from Delhi-NCR. The questionnaire was distributed to 450 working women, and 394 of them provided legitimate replies.

Results

Respondents' Demographic Profile

Out of 450 working women, only 394 were considered because some of the responses were incomplete. The data of 394 questionnaires was entered into the computer and Statistical Package for Social Science (SPSS) software was used for the analysis. Table 1 provides a description of the age, income, and occupation-based demographic analysis of working women of Delhi-NCR:

Table 1: Demographic Profile

		Frequency	Percent
Age	Below 25 years	79	20.1
	25-35 years	214	54.3
	35-45 years	85	21.6
	45 years and above	16	4.1
	Total	394	100.0
Education	12 th	23	5.8
	Graduation	112	28.4
	Post graduation	198	50.3
	Doctorate/ Ph.D.	31	7.9
	Professional courses	30	7.6
	Total	394	100.0
Income	Less than 5 lakhs	236	59.9
	5 lakhs- 10 lakhs	117	29.7
	10 lakhs-15 lakhs	32	8.1
	above 15 lakhs	9	2.3
	Total	394	100.0
Occupation	Private job	198	50.3
	Government job	111	28.2
	Self-employed	35	8.9
	Others	50	12.7
	Total	394	100.0

(Source: Author's contribution)

According to the table above, the majority of respondents are between the ages of 25 and 35 (54.3%), followed by the 35 to 45 age group (21.6%), the under 25 age group (20.1%), and those over 45 (4.1%). 50.3% of respondents are postgraduates, 28.4% are graduates, 7.9% are PhD, 7.6% have done professional courses and 5.8% are 12th graders. The majority of respondents (59.9%) earn less than 5 lakhs, followed by 29.7% who earn between 5 and 10 lakhs, 8.1% who earn between 10 and 15 lakhs, and 2.3% who earn more than 15 lakhs. Most respondents (50.3%) work in the private sector, 28.2% in the government, other jobs account for 12.7%, and 8.9% are self-employed.

Descriptive Statistics and Cronbach's Alpha Value

The mean and standard deviation were determined for all items in the current investigation. According to table 2, all the components- performance expectancy, social influence, facilitating conditions, hedonic motivation, Trust, attitude, and Behavioural intention had mean values more than 3 and standard deviations above and around 1.

Table 2: Descriptive statistics and Cronbach's alpha value

Construct	Item	Mean	S.D.	Cronbach's alpha
Performance expectancy	PE1	3.39	1.031	0.848
	PE2	3.48	1.039	
	PE3	3.42	1.014	
	PE4	3.45	1.035	
Social influence	SI1	3.30	1.121	0.848
	SI2	3.21	1.084	
	SI3	3.20	1.099	
	SI4	3.24	1.173	
Facilitating conditions	FC1	3.46	1.170	0.800
	FC2	3.40	1.027	
	FC3	3.43	1.037	
	FC4	3.38	1.047	
Hedonic motivation	HM1	3.20	1.107	0.801
	HM2	3.35	1.072	
	HM3	3.42	1.148	
	HM4	3.31	1.025	
Trust	TR1	3.32	1.055	0.887
	TR2	3.13	1.053	
	TR3	3.08	1.088	
	TR4	3.14	1.032	
	TR5	3.26	1.047	
Attitude	ATT1	3.27	1.203	0.933
	ATT2	3.29	1.225	
	ATT3	3.29	1.208	
	ATT4	3.28	1.187	
Behavioural intention	BIN1	3.36	1.089	0.863
	BIN2	3.27	1.080	
	BIN3	3.48	1.032	
	BIN4	3.34	1.174	
	BIN5	3.38	1.059	

(Source: Author's contribution)

Cronbach's alpha was also determined for all the factors included in the table above to ensure the data's reliability and validity. All the constructs had Cronbach's alpha values greater than 0.7, indicating that the data was reliable. Higher alpha values (more than 0.7) indicate more reliability (Sharma, 2016; Hajjar, 2018).

Exploratory Factor Analysis (EFA)

Factor analysis was done to assess the data's validity. The Kaiser-Meyer-Olkin Sampling Measure Adequacy measure ranges from 0 to 1, with values close to 1 desired. The absolute minimum is suggested to be 0.6.

Table 3: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.947
Bartlett's Test of Sphericity	Approx. Chi-Square	6873.529
	Df	435
	Sig.	.000

(Source: Author's contribution)

Here, value of KMO is 0.947 and value of Bartlett's Test is less than 0.5 which shows the validity of data. Both values are within the range required to continue with the factor analysis. Both numbers fall within the range needed to proceed with the factor analysis (Shrestha, 2021; Napitupulu et al., 2017; Jamil, et al., 2014; Williams et al., 2010; Kaiser, 1970). The goal of factor analysis is frequently to minimize data dimensionality while maintaining as much of the original variance as possible.

Table 4- Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.050	40.165	40.165	3.564	11.878	11.878
2	1.969	6.564	46.729	3.354	11.179	23.057
3	1.651	5.502	52.231	3.106	10.352	33.409
4	1.462	4.873	57.104	2.787	9.291	42.700
5	1.287	4.290	61.393	2.727	9.091	51.792
6	1.217	4.056	65.450	2.672	8.907	60.698
7	1.171	3.903	69.352	2.596	8.654	69.352
8	.689	2.297	71.650			
9	.630	2.100	73.750			
10	.610	2.032	75.782			
11	.575	1.917	77.699			
12	.527	1.757	79.456			
13	.492	1.640	81.096			
14	.471	1.569	82.664			
15	.453	1.511	84.176			
16	.441	1.470	85.645			
17	.412	1.375	87.020			
18	.404	1.348	88.368			
19	.383	1.277	89.645			
20	.366	1.220	90.865			
21	.360	1.202	92.067			
22	.349	1.164	93.231			
23	.326	1.085	94.316			
24	.323	1.076	95.393			
25	.304	1.012	96.405			
26	.289	.965	97.369			
27	.245	.818	98.188			
28	.190	.634	98.821			
29	.183	.610	99.431			
30	.171	.569	100.000			

(Source: Author's contribution)

A component with an eigenvalue larger than one explains more common variance than unique variance, indicating its significance (Shrestha, 2021; Pallant, 2020; Williams et al., 2010; Kaiser, 1970; Guttman, 1954). Seven variables with eigenvalues larger than one (Component 1-12.050, Component 2- 1.969, Component 3- 1.651, Component 4- 1.462, Component 5- 1.287, Component 6- 1.217, Component 7- 1.171) were found by principal component analysis (PCA) and varimax rotation. Eigenvalues indicate how much variance each component explains.

Table 5- Rotated Component Matrix

Rotated Component Matrix							
	Component						
	1	2	3	4	5	6	7
PE1					.732		
PE2					.720		
PE3					.704		
PE4					.683		
SI1				.778			
SI2				.791			
SI3				.744			
SI4				.579			
FC1						.738	
FC2						.758	
FC3						.600	
FC4						.738	
HM1							.725
HM2							.703
HM3							.722
HM4							.682
TR1	.707						
TR2	.775						
TR3	.785						
TR4	.773						
TR5	.648						
ATT1			.781				
ATT2			.796				
ATT3			.775				
ATT4			.755				
BIN1		.711					
BIN2		.704					
BIN3		.754					
BIN4		.750					
BIN5		.662					
Extraction Method: Principal Component Analysis.							
Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 6 iterations.							

(Source: Author's contribution)

Items with factor loadings greater than 0.5 were extracted from the rotated component matrix (see table 5). The findings of this investigation satisfied Hair et al.'s (2014) criteria. These loadings show the strength and direction of the relationship between each variable and the retrieved components. Higher absolute numbers suggest a stronger link.

Confirmatory Factor Analysis (CFA)

The purpose of CFA is to validate construct validity, which will serve as the foundation for additional investigations on the link between constructs and their constituents.

Table 6: Model Fit

Fit Indices	Recommended value	Model fit	References
CMIN/DF	≤ 5.00	1.291	Byrne (2016); Hair et al., (2010)
GFI	≥ 0.90	0.922	Hair et al., (2010)
AGFI	≥ 0.90	0.906	Hair et al., (2010)
NFI	≥ 0.90	0.930	Bentler and Bonnett (1980); Bollen (1989); Bagozzi & Yi, (1988); Byrne (2016); Schumacker and Lomax (2012); Hair et al. (2010)
CFI	≥ 0.90	0.983	Bentler (1990); Hair et al. (2010); Byrne (2016)
RMSEA	≤ 0.08	0.027	Steiger, (1998); Hair et al., (2010); Browne & Cudeck, (1992)

(Source: Author's contribution) Note: Recommended value source: (Sahoo, 2019)

According to table 6, CMIN/DF is 1.291, which should be less than 5, GFI is 0.922, NFI is 0.930, CFI is 0.983, which should be higher than 0.9, AGFI is 0.906 (should be more than 0.8), and RMSEA is 0.027 (should be less than 0.08). So, all the values are appropriate for the model.

Table 7: Convergent Validity

	CR	AVE	MSV	MaxR(H)
Trust	0.887	0.612	0.461	0.890
Social Influence	0.853	0.593	0.424	0.861
Facilitating Conditions	0.805	0.509	0.410	0.813
Hedonic Motivation	0.802	0.504	0.401	0.808
Behavioural Intention	0.864	0.560	0.416	0.866
Attitude	0.933	0.777	0.461	0.935
Performance Expectancy	0.848	0.583	0.424	0.850

(Source: Author's contribution)

All eight variables have a CR more than 0.7 and an AVE greater than 0.5. Table 7 further demonstrates that for all components, CR is bigger than AVE and AVE > MSV. Therefore, we may infer that the measurement model's components have enough convergent validity.

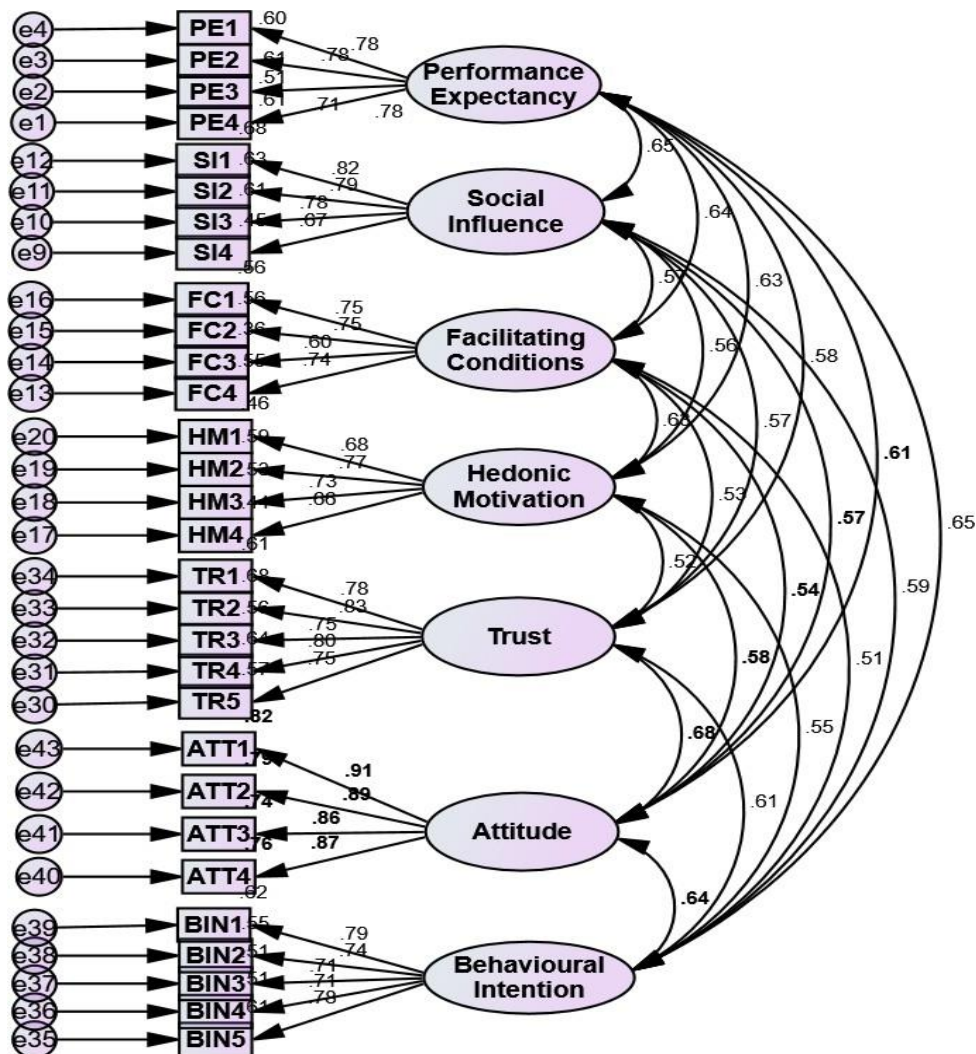
Table 8: Discriminant validity

	TR	SI	FC	HM	BIN	ATT	PE
TR	0.782						
SI	0.572	0.770					
FC	0.526	0.575	0.714				
HM	0.520	0.564	0.633	0.710			
BIN	0.611	0.592	0.506	0.554	0.748		
ATT	0.679	0.570	0.545	0.585	0.642	0.882	
PE	0.577	0.651	0.640	0.633	0.645	0.607	0.763

(Source: Author's contribution)

The Fornell-Larcker criterion for discriminant validity (Fornell & Larcker, 1981) was also examined which is considered as traditional method of evaluating discriminant validity (Hair et al., 2014). This criterion states that each construct's square root of the AVE must be greater than its highest correlation with any other construct (Afthanorhan W. M., 2013). According to table 8, discriminant validity is present in the current study since all the results fall within the range.

Figure 2: CFA Model



(Source: Author's contribution)

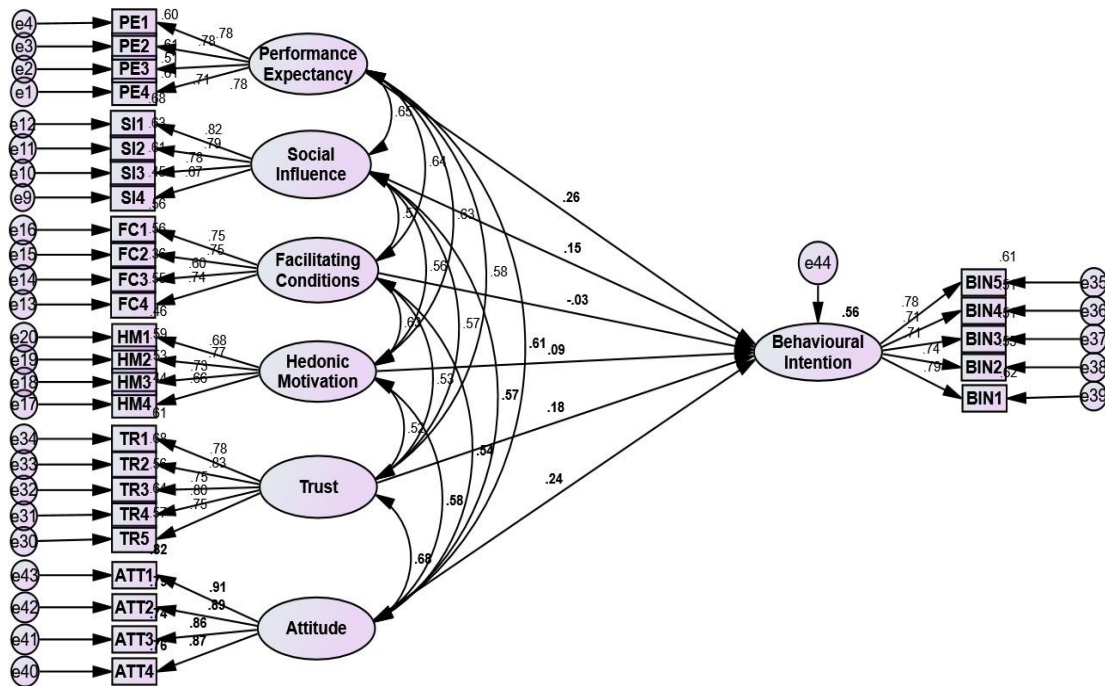
Structural Equation Modelling (SEM)

SEM is a statistical method that is highly recommended for characterizing the relationship between components (Hair, 2009). SEM efficiently replicates our comprehension of the entire hypothesized model through the interactions between several variables (Sahoo, 2019).

Hypotheses:

- 1) H₁: There is a significant relationship between Performance Expectancy and Behavioural Intention of working women to adopt social media platforms for fashion items.
- 2) H₂: There is a significant relationship between Social Influence and Behavioural Intention of working women to adopt social media platforms for fashion items.
- 3) H₃: There is a significant relationship between Facilitating Conditions and Behavioural Intention of working women to adopt social media platforms for fashion items.
- 4) H₄: There is a significant relationship between Hedonic Motivation and Behavioural Intention of working women to adopt social media platforms for fashion items.
- 5) H₅: There is a significant relationship between Trust and Behavioural Intention of working women to adopt social media platforms for fashion items.
- 6) H₆: There is a significant relationship between Attitude and Behavioural Intention of working women to adopt social media platforms for fashion items.

Figure 3: Structural Model



(Source: Author's contribution)

The R² (Coefficient of determination) value can range from 0 to 1 (Yıldız & Kelleci, 2023). The R² value for each endogenous (dependent) variable denotes the proportion of variation explained by the model for that variable. Behavioral Intention (BIN) has a R² of 0.56, indicating that other latent variables (Performance Expectancy, Social Influence, Facilitating conditions, Hedonic motivation, Trust, and Attitude) account for 56% of its variation.

Table 9– Results of standardized estimates of the structural model

Path			Estimate	S.E.	C.R.	P-value	Significance
BIN	<---	PE	.266	.080	3.314	***	YES
BIN	<---	SI	.154	.072	2.142	.032	YES
BIN	<---	FC	-.030	.077	-.392	.695	NO
BIN	<---	HM	.108	.088	1.226	.220	NO
BIN	<---	TR	.192	.071	2.711	.007	YES
BIN	<---	ATT	.191	.055	3.490	***	YES

(Source: Author's contribution)

As per table 9, hypotheses H₁ (PE → BIN), H₂ (SI → BIN), H₅ (TR → BIN) and H₆ (ATT → BIN) are significant as p-value is less than 0.05 for all. So, Performance expectancy, social influence, Trust, and Attitude have positive relation with the behavioural intention. Hypotheses, H₃ (FC → BIN) and H₄ (HM → BIN) are non-significant as all the p-values are greater than 0.05. Thus, facilitating conditions and Hedonic motivation do not have positive relation with the behavioural intention.

Implications and Recommendations

The findings of this study provided a substantial theoretical contribution to researchers in the relevant field of interest by capturing various crucial elements in the current study model. Initially, this study included four elements (Performance expectancy, social influence, facilitating conditions, and Hedonic motivation) from the UTAUT2 model (Venkatesh et al., 2012) and one factor (Attitude) from TPB and one factor (Trust) has been taken from literature. The study's findings shed light on the elements that influence working women's buying intentions on social media platforms for fashion items in Delhi-NCR. The study's findings offered numerous critical insights for marketers. This study gives valuable information and recommendations for social media marketers looking to tailor their marketing mix to match working women's expectations for online purchases for fashion items.

Performance Expectancy has been discovered to have a positive effect on working women's buying intentions for fashion items. This is because working women buy on social media platforms because these are helpful and make their lives simpler, therefore marketers may focus on the comfort factor when building their product and marketing mix on social media platforms. Social influence has been proven to have a positive impact on working women's purchase intentions, implying that working women are persuaded by others around them to buy fashion items on social media platforms. The social influence factors include peer influence, influencer marketing, and social media recommendations. Understanding and exploiting social impact aspects allows social media marketers to successfully interact with working women, establish trust, and create compelling shopping experiences that are tailored to their preferences and lifestyles.

Facilitating Conditions is not a significant predictor of working women's purchasing intentions, implying that working women lack the knowledge and resources to buy things on social media platforms. Marketers can focus on the following facilitating conditions: mobile accessibility, time savings, flexible payment alternatives, and customization. Thus, marketers should raise awareness by promoting customer participation on social media sites. Hedonic Motivation is not a major predictor of working women's purchase intention for fashion items, implying that they do not perceive social media sites to be particularly interesting or enjoyable for purchasing fashion items. As a result, it is possible to infer that by arranging gaming events and giving away free vouchers to winners, marketers may add an enjoyable aspect to their social media platforms. Trust and Attitude are significant predictors of purchase intention of working women for fashion items, which means working women find social media platforms valuable and trustworthy to buy fashion items.

Conclusion

The stated goal of this study was to uncover the important social media marketing aspects that might affect working women's purchase decisions for fashion items. After reviewing most of the literature in the field of social media marketing, this study concludes that four variables/factors (performance expectancy, social influence, Trust, and attitude) are the most important indicators of purchase/behavioral intention among working women for fashion items. Two factors (Facilitating conditions and Hedonic motivation) had insignificant impact on Behavioural intention. The data was obtained from 394 working women in Delhi-NCR, and it was then subjected to Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) before being analyzed

using SEM. The model suggested that four variables—performance expectancy, social influence, Trust, and attitude—are the most significant predictors of purchase intention of working women for fashion items.

Subsequently, the data obtained were reviewed in the context of both logical arguments and the conclusions from previous research on social media platforms (Alalwan et al., 2018) (Alalwan et al., 2017) (Gharaibeh et al., 2020) (Davis, 1989) (Eneizan et al. 2019). So, the current study's findings are supported by the literature on social media marketing, UTAUT2 (Unified Technology of Acceptance and Use of Technology), and TPB (Theory of Planned Behavior). Understanding working women's purchasing intentions on social media not only improves academic understanding, but also provides significant data for businesses looking to improve their marketing methods and attract this crucial client segment. Working women continue to be an important market group, especially as their digital engagement grows. These findings have consequences for decision-making and strategy design, particularly where changing behavioural intentions is a critical goal.

Limitations and Future scope

Although this study was effective in identifying the important elements that may impact working women's purchasing behavior on social media platforms, it has several limitations that should be addressed in future research-

- The major limitation of this study is that the investigation is confined to just working women from all cohorts. In future, other cohorts should also be considered, such as- Working men, non-working women, Students etc.
- Another limitation is that the study is limited to only fashion items, in future researches others categories should also be considered, such as- Accessories, mobile phones, laptops etc.
- Only Delhi-NCR has been included in the present study, in future other regions should also be explored to implement the results on national and international level.
- The sample size is small, in future the similar study can be conducted with a large sample to make the results better.

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Advances in Cancer Cell Research: Managing and Bridging Molecular Insights, Epigenetic Innovations, Artificial Intelligence, and Clinical Applications to Shape the Future of Precision Oncology and Sustainable Therapeutics

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Abstract

Cancer research has made remarkable strides in the past few decades, driven by innovations in precision medicine, immunotherapy, and advanced diagnostic tools. This paper provides an in-depth exploration of these advancements, focusing on the integration of molecular biology, artificial intelligence (AI), and sustainable practices in oncology. The study begins by examining the shift from traditional therapies, such as chemotherapy and radical surgeries, to targeted approaches like EGFR inhibitors, BCR-ABL inhibitors, and VEGF inhibitors. It highlights their success in improving patient outcomes while addressing the challenges posed by tumour heterogeneity and acquired resistance. The role of the tumour microenvironment (TME) and cancer stem cells (CSCs) in therapy resistance and recurrence is critically analysed, with insights into novel approaches targeting these components. Strategies like CAR-T cell therapies, immune checkpoint inhibitors, and combination immunotherapies underscore the importance of leveraging the immune system to combat cancer effectively. Advances in epigenetic therapies, such as histone deacetylase inhibitors and DNA methyltransferase inhibitors, showcase how gene expression modulation offers new hope for previously untreatable malignancies.

Delving into the transformative role of AI and machine learning in cancer diagnosis, prognosis, and drug discovery, and analysing large datasets, AI-driven models improve early detection, predict treatment responses, and accelerate the development of novel therapeutics. Additionally, liquid biopsies, a non-invasive diagnostic tool, are emphasized for their potential in real-time monitoring of disease progression and resistance mutations. To ensure sustainability, the study discusses the need for equitable access to these advanced therapies, particularly in low-resource settings. Emphasis is placed on scalable solutions such as telemedicine, mobile radiotherapy units, and global collaborations to bridge the gap in healthcare disparities. Finally, the integration of multi-omics data, combined with AI and innovative therapeutic strategies, is presented as a pathway to a more personalized and effective oncology paradigm. This paper not only addresses the scientific advancements reshaping cancer treatment but also highlights the importance of sustainability in research and healthcare delivery. By adopting innovative and inclusive strategies, the global oncology community can better combat cancer while ensuring equitable outcomes for all.

Keywords: Precision Medicine, Tumour Microenvironment (TME), Cancer Stem Cells (CSCs), Immunotherapy, Liquid Biopsy, Epigenetic Therapies, Targeted Therapies, Sustainable Healthcare, Multi-Omics Integration, Combination Therapy, Resistance Mechanisms, Oncology Innovations

Introduction

Historical Context of Cancer Treatments

The history of cancer treatment mirrors humanity's evolving scientific understanding. In the Edwin Smith Papyrus (~1700 BC), tumors were described as incurable, reflecting the rudimentary knowledge of the era. Early therapeutic interventions, rooted in the humoral theory of Hippocrates, attempted to restore bodily fluid balance through practices like bloodletting and cupping.

The advent of modern surgery in the 19th century marked a pivotal shift. William Halsted's **radical mastectomy**, premised on the theory of centrifugal cancer spread, demonstrated early success in local recurrence reduction, with recurrence rates falling to **6% locally** and **14% regionally**. Despite its efficacy in localized control, systemic failures became evident, with many patients succumbing to distant metastases. This underscored the need for integrated systemic and local treatment approaches.

Paradigm Shift: Systemic Disease Theories

In the mid-20th century, Bernard Fisher revolutionized cancer biology by positing that cancer is systemic from its inception. According to Fisher's theory, metastasis occurs early via the bloodstream, rendering extensive local surgeries insufficient. Randomized trials subsequently demonstrated that **lumpectomy combined with**

radiotherapy offered survival outcomes comparable to those of radical mastectomy, paving the way for more conservative surgical techniques.

Innovative Modalities in Cancer Treatment

Targeted Intra-Operative Radiotherapy (TARGIT): A Case Study in Precision

TARGIT epitomizes the evolution of cancer treatment toward precision medicine. This technique delivers a focused radiation dose directly to the tumor bed intra-operatively, sparing healthy tissues and obviating the need for prolonged post-operative radiotherapy.

Dosimetric Principles

Radiation dose effectiveness in TARGIT is quantified using the **Linear Quadratic Model**:

$$E=nD(1+D/(\alpha/\beta))$$

Where:

- E: Biological effect of radiation.
- n: Number of fractions.
- D: Dose per fraction.
- α/β : Ratio reflecting tissue radiosensitivity (10 Gy for tumors, 3 Gy for normal tissues).

Pilot Study Results

A TARGIT pilot study involving **26 patients** aged **30–80 years** yielded compelling results:

- **Local recurrence**: 0% over a **34-month** median follow-up.
- **Treatment time**: Reduced to **30 minutes** compared to conventional **6-week** regimens.
- **Patient satisfaction**: Rated at **95%**, attributed to reduced treatment burden and superior cosmetic outcomes.

Radiotherapy beyond TARGIT: Addressing Multicentricity

Multicentricity, characterized by the presence of multiple tumor foci within a single organ, presents a significant challenge in breast cancer treatment. Whole-organ analyses reveal that up to **63%** of mastectomy specimens harbor occult foci, though most are confined to within **2–4 cm** of the primary tumor.

TARGIT's Role

TARGIT addresses this challenge by delivering a concentrated dose to the tumor bed, effectively neutralizing residual malignant cells while avoiding unnecessary irradiation of distant foci.

Clinical Trial Insights

The Oxford Overview meta-analysis consolidated data from multiple trials, reinforcing that **localized recurrence rates** could be significantly reduced through targeted radiotherapy, with no impact on overall survival.

Methodical approach to Insights in Cancer Research data sampling and analysis and

Molecular Insights in Cancer Research

DNA Fingerprinting: Ensuring Research Integrity

The authenticity of cell lines is paramount in cancer research. Contamination and misidentification, affecting **18%** of research cell lines globally, compromise experimental reproducibility and validity. DNA fingerprinting provides a robust solution through high-resolution analysis of genetic polymorphisms.

Methodologies: VNTR and STR Analysis

- **VNTR (Variable Number Tandem Repeats)**: Exploits minisatellite regions for differentiation based on allele length.
- **STR (Short Tandem Repeats)**: Microsatellite markers, characterized by short, repeating sequences, enable precise genetic profiling.

Technical Application

Amplified Fragment Length Polymorphism (AmpFLP):

- DNA regions are amplified via Polymerase Chain Reaction (PCR).
- Electrophoresis segregates DNA fragments by size.
- Resulting profiles are matched against reference databases for verification.

Statistical Modelling and Data Analysis

Optimizing Radiation Therapy with Mathematical Models

Radiation dose optimization is essential in achieving therapeutic efficacy while minimizing side effects. The dosimetric profile of radiotherapy, particularly in TARGIT, is governed by dose distribution models.

Exponential Dose Attenuation Model

The following model predicts dose attenuation based on tissue depth:

$$D(x) = D_0 e^{-kx}$$

Where:

- $D(x)$: Radiation dose at depth x .
- D_0 : Surface dose.
- k : Attenuation constant (dependent on tissue properties).

For TARGIT, the surface dose (D_0) is typically **20 Gy**, attenuating to a therapeutic dose of **5 Gy** at **1 cm** depth.

Clinical Trial Data Insights

Meta-analyses play a pivotal role in synthesizing large-scale data. The **Oxford Overview**, analyzing trials across decades, confirmed equivalence in survival between conservative and radical surgeries, provided radiotherapy accompanies lumpectomy.

Summary of Results

Parameter	Lumpectomy + Radiotherapy	Radical Mastectomy
5-Year Survival (%)	87	86
Local Recurrence Rate (%)	10	6
Cosmetic Satisfaction (%)	92	40

The reduction in recurrence rates with radiotherapy underscores its adjunctive value, while superior cosmetic outcomes favor conservative approaches.

Predictive Modeling in Treatment Outcomes

Mathematical models assist in predicting recurrence risks and optimizing therapy protocols. A commonly used predictive model incorporates tumor doubling time (T_d) and treatment delay (T_{delay}):

$$R_{rec} = R_0 e^{\lambda T_{delay}}$$

Where:

- R_{rec} : Recurrence risk.
- R_0 : Baseline recurrence probability.
- λ : Growth constant related to T_d .

Application:

For a tumor with $T_d=60 = 60$ days and $T_{\text{delay}}=30T_{\text{delay}} = 30$ days:

$$\lambda = \ln(2)/T_d = 0.0116 \text{ per day}$$

$$R_{\text{rec}} = R_0 e^{0.0116 \cdot 30} \approx R_0 \cdot 1.39$$

This calculation demonstrates how delays in treatment amplify recurrence risks, reinforcing the need for timely interventions.

Challenges in Treatment Personalization

Tumour Heterogeneity and Genomic Insights

Tumour heterogeneity poses a formidable challenge to treatment uniformity. Advances in next-generation sequencing (NGS) reveal significant inter- and intra-tumoral genetic variability, necessitating personalized therapies.

Key Findings from Genomic Profiling:

- **BRCA Mutations:** Strong predictors of response to PARP inhibitors.
- **HER2 Overexpression:** Linked to improved outcomes with targeted monoclonal antibodies like trastuzumab.

Personalized treatment frameworks integrate these markers to tailor therapeutic strategies, enhancing efficacy.

Addressing Disparities in Access to Care

Geographical and socioeconomic barriers hinder equitable access to advanced treatments like TARGIT. Strategies to mitigate these disparities include:

- Establishing **mobile radiotherapy units** for rural regions.
- Leveraging **telemedicine platforms** to deliver patient follow-ups and education.

Technological Innovations in Cancer Research

Artificial Intelligence in Oncology

Artificial Intelligence is revolutionizing cancer diagnostics and treatment planning. Algorithms trained on imaging data identify tumor boundaries with unprecedented accuracy, guiding precision surgeries.

AI Applications:

- **Radiomics:** Extracting quantitative features from imaging data to predict treatment outcomes.
- **Predictive Analytics:** Forecasting patient responses to chemotherapy based on historical datasets.

Advancements in Imaging Modalities

Modern imaging techniques enhance tumor visualization, aiding in diagnosis and intra-operative decision-making.

Comparative Analysis of Imaging Modalities:

Modality	Sensitivity (%)	Applications
MRI	95	Detecting multicentricity
PET-CT	90	Identifying metastases
Mammography	85	Screening for early lesions

Integration of Molecular Diagnostics

Techniques like liquid biopsies are gaining traction for their minimally invasive nature. These tests detect circulating tumor DNA (ctDNA) and exosomes, providing real-time insights into tumor dynamics.

Data Integration for Comprehensive Care

Combining clinical, genomic, and imaging data within unified platforms facilitates precision oncology. AI-driven analytics synthesize these datasets, offering holistic patient management.

The integration of molecular diagnostics, personalized therapies, and AI-driven tools heralds a new era in cancer care. Future research priorities include:

- Expanding TARGIT's application beyond breast cancer to other solid tumors.
- Developing biomarkers for predicting treatment resistance.
- Establishing global collaborations for equitable access to advanced technologies.

The Role of Local Therapies in Cancer Management

Local therapies, including surgery and radiotherapy, are critical in controlling tumor growth at the primary site. While radical approaches dominated early cancer treatment, modern strategies emphasize precision and minimal invasiveness.

Comparative Effectiveness of Local Therapies:

Therapy Type	Primary Outcome	Associated Challenges
Radical Surgery	High local control	Increased morbidity, scarring
Conservative Surgery	Comparable survival rates	Risk of residual disease
Radiotherapy (TARGIT)	Reduced treatment time, improved cosmetic outcomes	Accessibility in remote areas

Conservative approaches like TARGIT combine precision with efficacy, representing a paradigm shift in localized cancer care.

Systemic Therapy Innovations

Systemic therapies address metastases and microscopic disease beyond the primary site. Developments in chemotherapy, immunotherapy, and targeted treatments have significantly improved survival rates.

Immunotherapy: Revolutionizing Cancer Treatment

Immune checkpoint inhibitors (e.g., pembrolizumab) unleash the immune system's potential by targeting molecules like PD-1 and CTLA-4.

Mechanism of Action:

Checkpoint inhibitors block suppressive signals within T cells, enabling an amplified immune response against tumor cells. This approach has demonstrated exceptional efficacy in malignancies like melanoma and lung cancer.

Limitations:

Despite promising outcomes, challenges include immune-related adverse events (irAEs) and variable patient responses, often driven by tumor mutational burden and the immune microenvironment.

Synergistic Approaches: Combining Local and Systemic Therapies

The integration of local and systemic treatments offers a comprehensive strategy for cancer care. Examples include:

- **Neoadjuvant Therapy:** Systemic treatments administered pre-operatively to shrink tumors, facilitating conservative surgeries.
- **Adjuvant Radiotherapy:** Delivered post-surgery to eradicate microscopic disease, enhancing long-term control.

Molecular and Cellular Advances

Role of Tumour Microenvironment in Therapy Resistance

The tumour microenvironment (TME) comprises cellular and extracellular components that influence treatment outcomes. Hypoxic conditions within the TME, for instance, reduce radiotherapy efficacy by impairing reactive oxygen species (ROS) generation.

Emerging Solutions:

- **Hypoxia-Activated Prodrugs:** Selectively target hypoxic tumor cells.
- **Oxygen Delivery Systems:** Enhance radiotherapy efficacy by normalizing TME oxygenation.

Role of Cancer Stem Cells (CSCs)

CSCs are a subpopulation within tumors capable of self-renewal and driving recurrence. Their inherent resistance to conventional therapies necessitates innovative targeting strategies.

Potential Approaches:

- **Wnt/Beta-Catenin Inhibitors:** Block critical CSC signaling pathways.
- **Nanoparticle-Based Delivery:** Enhances the specificity and bioavailability of CSC-directed agents.

Clinical Trial Frameworks and Ethical Considerations

The Importance of Adaptive Clinical Trials

Traditional clinical trial designs often fail to address the dynamic nature of cancer progression and treatment responses. Adaptive designs, in contrast, allow modifications to trial protocols based on interim results, optimizing patient outcomes.

Features of Adaptive Trials:

- Real-time data integration for treatment adjustments.
- Enhanced efficiency by identifying effective therapies earlier.
- Reduction in patient exposure to ineffective treatments.

Example: I-SPY 2 Trial

The I-SPY 2 trial for breast cancer dynamically assigns patients to therapies based on predictive biomarkers, accelerating the identification of successful combinations.

Mathematical and Computational Models in Oncology

Modeling Tumor Growth Dynamics

Mathematical models provide quantitative frameworks to simulate tumor growth and treatment responses.

Gompertzian Growth Model:

This model describes tumor growth as initially exponential, followed by saturation due to resource constraints:

$$V(t) = V_0 e^{\frac{A}{B}(1 - e^{-Bt})}$$

Where:

- $V(t)$: Tumor volume at time t .
- V_0 : Initial tumor volume.
- A, B : Growth parameters influenced by tumor biology.

Application:

Predicting tumor shrinkage following chemotherapy to optimize dosing schedules.

Computational Simulations in Radiotherapy Planning

Advanced simulations incorporate imaging data to personalize radiotherapy. Monte Carlo methods, for instance, model radiation transport and dose deposition with high precision.

Case Study: Monte Carlo Simulation for Lung Cancer

- Inputs: Patient-specific CT scans, tumor boundaries, and tissue density maps.
- Outputs: Optimized dose distributions minimizing collateral damage to healthy tissues.

Use of neural networking models and AI accelerate drug development by identifying potential compounds and predicting their biological activity. Deep learning algorithms analyze large datasets, uncovering patterns undetectable by traditional methods, e.g. AlphaFold's protein structure predictions enhance the design of targeted therapies by elucidating drug-target interactions.

The convergence of molecular biology, computational tools, and clinical innovation heralds a transformative era in cancer care. Key directions include:

Integrating Multi-Omic Data: Unifying genomic, proteomic, and metabolomic insights for holistic understanding.

Expanding Accessibility: Bridging gaps in healthcare equity through technological and policy reforms.

Advancing AI Applications: From real-time treatment adjustments to predictive analytics, AI will redefine precision oncology.

Advanced Treatment Modalities: Personalized and Combination Therapies

Personalized Oncology

The era of precision medicine is rooted in understanding patient-specific tumor biology. Tailored therapies target genetic mutations, expression profiles, and epigenetic markers unique to an individual's cancer.

Genomic Profiling and Targeted Therapies

Large-scale sequencing projects, such as The Cancer Genome Atlas (TCGA), have identified actionable mutations in key oncogenes and tumor suppressors (e.g., KRAS, EGFR). These findings have spurred the development of molecularly targeted agents, such as:

- **EGFR Inhibitors:** Gefitinib for EGFR-mutant non-small cell lung cancer (NSCLC).
- **BRAF Inhibitors:** Dabrafenib for BRAF V600E-mutant melanoma.

Pharmacogenomics: Enhancing Efficacy and Reducing Toxicity

By incorporating patient-specific genomic data, pharmacogenomics identifies optimal drug regimens, minimizing adverse effects while maximizing efficacy.

Combination Therapies

Cancer's inherent heterogeneity often necessitates multi-modal treatment approaches. Combination therapies leverage synergies between modalities to overcome resistance mechanisms.

Case Study: Triple-Negative Breast Cancer (TNBC)

TNBC, characterized by the absence of ER, PR, and HER2, poses therapeutic challenges due to its aggressive nature. Combination approaches include:

- **Chemotherapy + Immunotherapy:** The IMpassion130 trial showed that adding atezolizumab (an anti-PD-L1 antibody) to nab-paclitaxel improved progression-free survival in metastatic TNBC.
- **PARP Inhibitors + Chemotherapy:** Synergistic efficacy in BRCA-mutated TNBC.

Mathematical Modeling for Optimal Synergy

The Bliss Independence Model predicts the additive or synergistic effects of combination therapies:

$$E_{\text{combo}} = EA + EB - (EA \cdot EB)$$

Where:

- EA, EB: Efficacy of individual agents.
- Ecombo: Combined efficacy.

Exploring the Immune Landscape

Tumor Immunoediting and Escape Mechanisms

Tumor progression involves immune system interactions, described by the “immunoediting” framework:

- **Elimination:** Immune system detects and eradicates transformed cells.
- **Equilibrium:** Dormant cancer cells persist in a controlled state.
- **Escape:** Tumors evade immune surveillance through mechanisms like PD-L1 overexpression or recruitment of suppressive cells (e.g., Tregs).

Emerging Immune-Based Interventions

- **Chimeric Antigen Receptor (CAR) T-Cells:** Engineered T-cells that recognize specific tumor antigens (e.g., CD19 for B-cell malignancies).
- **Neoantigen Vaccines:** Personalized vaccines based on tumor-specific mutations.

The Role of Biomarkers in Immunotherapy

Biomarkers predict patient response and guide immunotherapy decisions. Notable examples include:

- **Tumor Mutational Burden (TMB):** Correlates with checkpoint inhibitor efficacy.
- **Microsatellite Instability (MSI):** Predicts response to pembrolizumab in colorectal cancer.

Case Study: TMB as a Predictor

High TMB (>10 mutations/Mb) is associated with durable responses to PD-1 blockade. However, low TMB tumors may still respond if they exhibit other immunogenic features, such as neoantigen expression.

Single-Cell Sequencing

Single-cell RNA sequencing (scRNA-seq) provides high-resolution insights into tumor heterogeneity by analyzing individual cells within the tumor microenvironment.

Applications in Oncology:

- Identifying rare cell populations, such as CSCs.
- Mapping cellular trajectories during tumor evolution.
- Predicting resistance mechanisms to therapy.

Such a study of glioblastoma using scRNA-seq revealed distinct subpopulations with differential expression of resistance-associated genes, guiding therapeutic strategy development.

Liquid Biopsies: Non-Invasive Diagnostics

Liquid biopsies analyze circulating tumor DNA (ctDNA), exosomes, and tumor-derived cells in blood samples. These tools enable:

- **Early Detection:** Identifying ctDNA mutations in early-stage cancers.
- **Real-Time Monitoring:** Tracking response to therapy and detecting resistance mutations.

Technical Challenges and Innovations:

- **Sensitivity:** Enhanced by digital droplet PCR (ddPCR) and next-generation sequencing.
- **Standardization:** Developing protocols for ctDNA quantification and analysis.

Advancing the Role of Cancer Immunotherapy

Immune Checkpoint Inhibitors: Expanding Horizons

Immune checkpoint inhibitors (ICIs) have revolutionized cancer immunotherapy, targeting immune-suppressive pathways that tumor cells exploit to evade immune detection. PD-1, PD-L1, and CTLA-4 inhibitors are currently the most widely utilized ICIs. Their impact has been profound, especially in cancers like melanoma, NSCLC, and head and neck squamous cell carcinoma (HNSCC).

Mechanism of Action

Immune checkpoint inhibitors prevent the binding of checkpoint proteins (e.g., PD-L1 on tumors to PD-1 on T-cells), which normally dampen immune responses. This blockade enhances the immune system's ability to recognize and destroy tumor cells.

Case Study: PD-1/PD-L1 Inhibition

The **KEYNOTE-001** trial, which evaluated pembrolizumab (anti-PD-1), demonstrated a response rate of **45%** in advanced melanoma, with durable responses seen in many patients. Similar results have been observed in other cancers, but challenges remain in identifying biomarkers for response.

Resistance to ICIs

Resistance to immune checkpoint inhibitors remains a significant issue, often caused by:

- **Low Tumor Mutational Burden (TMB):** Cancers with fewer mutations may lack the diversity of neoantigens necessary for immune recognition.
- **Immunosuppressive Tumor Microenvironment (TME):** Tumors may recruit immunosuppressive cells like Tregs and myeloid-derived suppressor cells (MDSCs), which inhibit the action of T-cells.

Overcoming Resistance with Combination Immunotherapy

Combining ICIs with other immunotherapies or treatments holds the potential to overcome resistance. Some promising combinations include:

- **CTLA-4 + PD-1 Inhibition:** The combination of ipilimumab (anti-CTLA-4) and nivolumab (anti-PD-1) has demonstrated impressive results in metastatic melanoma, with **median overall survival (OS)** extending beyond 5 years in a subset of patients.
- **Chemotherapy + ICIs:** Chemotherapy may act by increasing T-cell priming and enhancing the efficacy of ICIs. Studies have shown that chemotherapy-induced tumor death releases neoantigens, providing additional targets for immune cells.

In **NSCLC**, the combination of **nivolumab** and **chemotherapy** led to significantly improved progression-free survival (PFS) compared to chemotherapy alone, resulting in its FDA approval for first-line treatment in patients without driver mutations.

The Role of Cancer Vaccines

Cancer vaccines are classified into two broad categories:

- **Active Vaccines:** Designed to stimulate the immune system to recognize and attack cancer cells by presenting specific tumor antigens.
- **Passive Vaccines:** Involve the infusion of ready-made antibodies or T-cells to fight cancer.

Example of Active Vaccine:

The **Cervarix** and **Gardasil** vaccines against **HPV** have been highly successful in preventing cervical cancer, showing how prophylactic vaccines can reduce cancer incidence by targeting oncogenic viruses.

Example of Passive Vaccine:

Kymriah, an autologous CAR-T cell therapy for leukemia, represents a significant step in using engineered T-cells as passive cancer vaccines. In the **ELIANA trial**, **83%** of pediatric and young adult patients with relapsed or refractory B-cell acute lymphoblastic leukemia (ALL) achieved remission with CAR-T cell therapy.

Tumor Antigens and Vaccine Targets

The discovery of **tumor-associated antigens (TAAs)** has paved the way for the development of therapeutic vaccines. These antigens are present in higher quantities or with altered forms in tumor cells compared to normal cells.

Key Tumor Antigens:

- **HER2:** Overexpressed in certain breast cancers, making it a target for trastuzumab (Herceptin) and vaccine-based therapies.
- **Mucin-1 (MUC-1):** Abnormally expressed in several epithelial cancers, including breast, lung, and ovarian cancers.

Challenges in Vaccine Development

Despite the promise of cancer vaccines, several challenges persist:

- **Tumor Heterogeneity:** Tumors evolve genetically, making it difficult to identify universal antigens.

- **Immune Tolerance:** Tumor cells may suppress immune responses, making it difficult for vaccines to initiate a robust immune response.

Nanotechnology in Cancer Treatment: The Potential of Nanoparticles for Targeted Delivery

Nanotechnology has emerged as a promising field for improving the delivery of chemotherapeutic agents, reducing systemic toxicity, and enhancing tumor specificity. Nanoparticles, with diameters typically in the range of **1-100 nm**, can encapsulate drugs and target them specifically to cancer cells.

Mechanisms of Action

Nanoparticles can be designed to release their payload in response to specific stimuli, such as changes in pH or temperature within the tumor microenvironment. For instance:

- **Liposomes:** Lipid-based nanoparticles that encapsulate chemotherapy agents, such as doxorubicin, and allow for targeted delivery.
- **Gold Nanoparticles:** These have unique optical properties that enable them to be used for both diagnostic imaging and therapy.

Example: Doxil, a liposomal formulation of doxorubicin, has improved outcomes in ovarian cancer and HIV-related Kaposi's sarcoma, with reduced side effects due to targeted delivery.

Diagnostic Nanoparticles: A New Era in Early Detection

Nanoparticles also play a significant role in diagnostics, with functionalized nanoparticles being used in imaging and biosensing. They can be designed to bind specifically to biomarkers found on tumor cells, enabling early detection even before clinical symptoms appear.

Case Study: In breast cancer, gold nanoparticles functionalized with **HER2 antibodies** have been used for imaging, helping clinicians to detect **small tumor sizes** that would otherwise be missed by conventional methods like mammography.

Mathematical Models in Cancer Treatment Decision-Making

Models for Predicting Treatment Response

Mathematical models help predict the efficacy of cancer treatments and guide clinical decision-making. These models integrate tumor growth dynamics, therapeutic dosing regimens, and individual patient variables to forecast outcomes.

Gompertzian Growth Model in Therapy Prediction

The Gompertzian model is often used to model tumor growth, especially in solid tumors. It assumes that tumor growth is exponential initially but slows as it approaches a carrying capacity determined by the tumor's interaction with the surrounding environment. The model is expressed as:

$$V(t) = V_0 e^{\frac{A}{B}(1 - e^{-Bt})}$$

Where:

- $V(t)$: Tumor volume at time t .
- V_0 : Initial tumor volume.
- A, B : Parameters governing the growth rate and carrying capacity.

Application:

This model helps clinicians determine the timing and dosage of chemotherapy required to optimally reduce tumor mass without causing excessive side effects or resistance.

Predicting and Overcoming Drug Resistance

Drug resistance remains a major challenge in cancer therapy, and mathematical models help predict potential pathways of resistance. Models can simulate the tumor's response to targeted therapies, accounting for factors like:

- **Tumor Mutations:** Resistance can emerge from pre-existing mutations or through the acquisition of new mutations.

- **Drug Efflux Pumps:** Some tumors overexpress proteins that pump chemotherapy drugs out of cells, reducing drug efficacy.

Example:

In **ovarian cancer**, mathematical models have been used to predict the emergence of resistance to platinum-based therapies, allowing for early interventions with alternative agents.

Emerging Therapies and Technologies in Cancer

Targeted Therapy: The Next Frontier

Targeted therapies have rapidly transformed the landscape of cancer treatment, particularly in cancers with defined genetic mutations. These therapies act on specific molecular targets associated with cancer, offering more precise treatment options with fewer side effects compared to traditional chemotherapy.

Examples of Targeted Agents:

- **EGFR Inhibitors (e.g., Erlotinib, Gefitinib):** These inhibitors target the epidermal growth factor receptor (EGFR), which is commonly overexpressed in lung, head and neck, and colorectal cancers.
- **BCR-ABL Inhibitors (e.g., Imatinib):** This class of drugs targets the BCR-ABL fusion protein, a hallmark of chronic myelogenous leukemia (CML).
- **VEGF Inhibitors (e.g., Bevacizumab):** Anti-vascular endothelial growth factor (VEGF) therapies block the formation of new blood vessels (angiogenesis) in tumors, starving the cancer of nutrients and oxygen.

Mechanisms of Action

Targeted therapies are designed to interfere with specific molecules involved in cancer cell growth. These therapies can block the activity of overactive oncogenes, inhibit tumor angiogenesis, or repair abnormal DNA in tumor cells.

Overcoming Challenges in Targeted Therapy

Despite their promising potential, targeted therapies face significant challenges:

- **Acquired Resistance:** Tumors can develop resistance to targeted therapies through mutation or activation of alternative signaling pathways.
- **Tumor Heterogeneity:** Even within a single tumor, different subpopulations of cells may express different genetic mutations, complicating the effectiveness of a single-target drug.
- **Off-Target Effects:** Some targeted therapies may affect non-cancerous cells with similar molecular markers, leading to unintended side effects.

Case Study: Targeting BRAF in Melanoma

BRAF mutations occur in approximately 50% of melanomas and are a key target for therapies like **Vemurafenib** and **Dabrafenib**. However, resistance develops in many cases, either through reactivation of the MAPK pathway or mutations in other genes such as NRAS. In response, combination therapies involving BRAF and MEK inhibitors (e.g., **Cobimetinib**) have been developed to prevent resistance and improve outcomes.

Cancer Metabolism and Therapeutic Targeting

The Role of Cancer Metabolism in Tumor Growth

Cancer cells exhibit altered metabolism, often described as the "Warburg effect," in which cells predominantly generate energy through glycolysis rather than oxidative phosphorylation, even in the presence of oxygen. This shift allows for the rapid proliferation of cancer cells and contributes to the tumor's survival in nutrient-deprived environments.

Key Metabolic Targets:

- **Hexokinase 2 (HK2):** Involved in the first step of glycolysis, overexpressed in many cancers.
- **Pyruvate Kinase M2 (PKM2):** A critical enzyme in glycolysis that favors cancer cell proliferation.
- **IDH1/2 Mutations:** These mutations are found in several cancers, including glioma and acute myeloid leukemia (AML), and result in the production of an oncometabolite, 2-hydroxyglutarate, which promotes tumorigenesis.

Targeting these metabolic pathways can deprive cancer cells of the energy they need for growth and survival.

Metabolic Inhibition in Cancer Therapy

Targeting cancer metabolism offers a novel therapeutic approach. Drugs that inhibit key metabolic enzymes have been tested in clinical trials, with varying degrees of success.

Example: Targeting Glycolysis with 3-Bromopyruvate

3-Bromopyruvate (3BP) is a compound that inhibits glycolysis by targeting hexokinase 2. Preclinical studies have shown that 3BP effectively inhibits the growth of several cancers, including liver cancer and colorectal cancer. However, its clinical application has been limited by issues with drug delivery and toxicity.

Example: Inhibiting the IDH1 Mutation

IDH1 inhibitors, such as **AG-120**, have shown promise in treating IDH1-mutated gliomas and AML. These inhibitors work by preventing the conversion of isocitrate to 2-hydroxyglutarate, reducing the oncometabolite's accumulation and thus inhibiting tumor growth.

Gene Therapy and CRISPR in Cancer Treatment

Gene Editing: The Promise of CRISPR-Cas9

The advent of CRISPR-Cas9 technology has revolutionized gene therapy by allowing for precise editing of the genome. This technology enables scientists to target and correct specific mutations that drive cancer development, offering a potential cure for genetically driven cancers.

Applications in Cancer:

- **Gene Correction:** CRISPR can be used to repair mutations in tumor-suppressor genes such as TP53 or PTEN, which are commonly altered in cancer.
- **Immune System Enhancement:** CRISPR has been used to modify T-cells to express chimeric antigen receptors (CAR), creating more potent CAR-T cell therapies for cancers like leukemia and lymphoma.

Case Study: CRISPR in Lung Cancer

In preclinical models, CRISPR has been used to knockout the **EGFR** mutation, a common driver in non-small cell lung cancer (NSCLC), leading to the inhibition of tumor growth and improved survival. Clinical trials for CRISPR-based therapies are still in their infancy but hold promise for targeting genetic drivers of cancer.

Challenges in Gene Therapy for Cancer

Despite the promise of gene therapy and CRISPR, several challenges need to be addressed:

- **Delivery Methods:** Efficient delivery of gene-editing tools to cancer cells remains a significant hurdle. Viral vectors, nanoparticles, and electroporation are among the methods being explored.
- **Off-Target Effects:** The risk of unintended edits, which could cause harmful mutations or activate oncogenes, is a concern for clinical applications.
- **Ethical Considerations:** Gene therapy raises significant ethical issues, particularly regarding germline editing and potential unintended long-term effects.

The Role of Epigenetics in Cancer

Epigenetic Modifications and Cancer

Epigenetics refers to the heritable changes in gene expression that do not involve alterations in the DNA sequence itself. These modifications, such as DNA methylation, histone modification, and non-coding RNA regulation, can significantly influence tumor development, progression, and response to treatment.

Key Epigenetic Mechanisms:

- **DNA Methylation:** Addition of a methyl group to the cytosine residues in CpG islands, often leading to gene silencing. Aberrant hypermethylation of tumor suppressor genes such as **p16INK4a** and **BRCA1** has been observed in various cancers, including lung and breast cancers.
- **Histone Modification:** The addition or removal of chemical groups to histones can alter chromatin structure and gene expression. Modifications such as acetylation and methylation of histones have been shown to either activate or repress transcription.

- **Non-Coding RNAs:** MicroRNAs (miRNAs) and long non-coding RNAs (lncRNAs) are involved in the regulation of gene expression at the post-transcriptional level. Dysregulated miRNA expression is implicated in the development of many cancers, including gastric, prostate, and breast cancer.

Epigenetic Therapy in Cancer

Given the critical role of epigenetic changes in cancer, targeting these modifications has emerged as a promising therapeutic approach. Epigenetic drugs aim to reverse the aberrant changes in gene expression that contribute to cancer progression.

Examples of Epigenetic Therapies:

- **DNA Methyltransferase Inhibitors:** Drugs such as **5-azacytidine** and **decitabine** inhibit DNA methylation, potentially restoring the expression of tumor suppressor genes in cancers such as myelodysplastic syndromes and acute myeloid leukemia (AML).
- **Histone Deacetylase Inhibitors (HDACi):** HDAC inhibitors such as **vorinostat** and **romidepsin** aim to prevent the deacetylation of histones, leading to an open chromatin structure and reactivation of tumor suppressor genes. HDAC inhibitors have been used in treating T-cell lymphomas and are being explored in combination therapies for other cancers.
- **BET Inhibitors:** Bromodomain and extra-terminal domain (BET) inhibitors target the interaction between acetylated histones and BET family proteins, which regulate the expression of genes involved in cell growth and survival. These inhibitors have shown promise in hematologic malignancies and solid tumors.

Challenges in Epigenetic Therapy:

Despite promising results, there are several challenges to the widespread use of epigenetic therapies:

- **Tumor Specificity:** Identifying the correct epigenetic targets in different types of tumors remains a challenge.
- **Off-Target Effects:** Epigenetic drugs may affect normal cells, leading to toxicity or side effects.

Resistance Mechanisms: Cancer cells can develop resistance to epigenetic therapies by altering their epigenetic profiles.

Liquid Biopsy: Revolutionizing Early Cancer Detection

Liquid biopsy is a non-invasive diagnostic tool that analyzes tumor-derived components from bodily fluids, such as blood, urine, or saliva. These components include circulating tumor DNA (ctDNA), circulating tumor cells (CTCs), exosomes, and microRNAs. Liquid biopsy offers a promising alternative to tissue biopsies for cancer diagnosis, monitoring, and prognostication.

Key Advantages of Liquid Biopsy:

- **Non-invasive:** Provides a less invasive alternative to traditional tissue biopsy, which can be painful and difficult to perform repeatedly.
- **Real-Time Monitoring:** Liquid biopsies enable the monitoring of tumor dynamics in real-time, including the detection of mutations or resistance markers as treatment progresses.
- **Early Detection:** Liquid biopsy can potentially detect cancers at an early stage, when the tumor is localized and more treatable, as well as monitor minimal residual disease after treatment.

Clinical Applications of Liquid Biopsy

Liquid biopsy is becoming an invaluable tool in clinical practice, with multiple applications across different stages of cancer care:

Early Detection of Cancer: Liquid biopsy can be used to detect ctDNA or CTCs in early-stage cancers, offering the potential for screening asymptomatic individuals before they develop clinical symptoms. For example, the detection of **EGFR mutations** in lung cancer patients using liquid biopsy can identify the disease at an earlier stage, improving survival outcomes by enabling earlier intervention.

Therapy Monitoring and Prognosis: During cancer treatment, liquid biopsies can track changes in ctDNA levels, providing real-time information on how well a patient is responding to therapy. Rising ctDNA levels may indicate disease progression, even in the absence of clinical symptoms or imaging changes. This enables clinicians to adjust treatments before clinical relapse occurs.

Identification of Resistance Mutations : Liquid biopsy is also used to detect emerging resistance mutations, which can guide treatment decisions. For example, in non-small cell lung cancer (NSCLC), liquid biopsies can identify **EGFR T790M** mutations that confer resistance to first-line EGFR inhibitors, enabling physicians to switch to second-line therapies such as **Osimertinib**.

Case Study: Liquid Biopsy in NSCLC

In a study of **EGFR-mutant NSCLC**, liquid biopsy was used to track **T790M mutations** during the course of treatment with EGFR tyrosine kinase inhibitors (TKIs). The liquid biopsy approach detected T790M mutations in ctDNA before they were identified through imaging or tissue biopsy, allowing for the early introduction of **Osimertinib** and significantly improving patient outcomes.

Challenges and Limitations of Liquid Biopsy

While liquid biopsy holds great promise, several challenges must be addressed before it can be widely adopted:

- **Sensitivity and Specificity:** Liquid biopsy is still less sensitive than traditional tissue biopsies, particularly in early-stage cancers or low-burden tumors. Detecting ctDNA or CTCs at low levels requires highly sensitive assays.
- **Standardization:** There is a lack of standardized protocols for liquid biopsy collection, processing, and analysis, which can lead to variability in results.
- **Regulatory Approval:** As a relatively new technology, liquid biopsy assays are still undergoing regulatory review, and the process for establishing clinical validity and utility is ongoing.

Shaping the Future of Cancer Treatment: A New Horizon

Artificial Intelligence and Machine Learning in Cancer Research

AI and Machine Learning in Early Diagnosis

Artificial intelligence (AI) and machine learning (ML) are rapidly transforming cancer diagnostics by providing tools for early detection, improving accuracy, and aiding in treatment decisions. AI algorithms are increasingly being used to analyze medical imaging, genomic data, and patient records, offering enhanced diagnostic capabilities.

Applications in Imaging:

AI-powered tools for radiology and pathology can automatically analyze medical images (such as CT scans, MRIs, and X-rays) and detect subtle patterns that may be overlooked by human experts. These tools use deep learning, a subset of machine learning, to recognize complex patterns in data. For example, deep convolutional neural networks (CNNs) are being used to identify features associated with lung cancer, breast cancer, and other malignancies in medical images.

Case Study: AI in Breast Cancer Detection: A recent study demonstrated that an AI model trained on mammogram images achieved a breast cancer detection accuracy of 94%, surpassing human radiologists. The model also reduced false positives, which often lead to unnecessary biopsies and patient anxiety.

AI in Personalized Treatment and Drug Development

AI and ML also play a significant role in **personalized cancer treatment** by predicting how patients will respond to specific therapies based on their genetic and molecular profiles.

Applications:

- **Predicting Drug Response:** AI algorithms can analyze large datasets, including genomic and proteomic data, to predict how different patients will respond to various cancer therapies. For example, **IBM Watson for Oncology** uses AI to analyze clinical trial data and patient records to recommend the most appropriate treatment based on the patient's tumor characteristics.
- **Drug Discovery:** AI can accelerate the identification of potential drug candidates by analyzing vast chemical libraries and predicting which compounds are most likely to be effective against specific cancer types. ML algorithms are used to predict the binding affinity of molecules to target proteins, speeding up the drug discovery process.

Case Study: AI in Drug Repurposing: In the fight against COVID-19, AI-based drug repurposing efforts led to the identification of **baricitinib** as a potential treatment. Similarly, AI is being used to identify existing drugs that could be repurposed for cancer therapy, reducing the time and cost of drug development.

Therapeutic Cancer Vaccines

While preventive vaccines like those for HPV and hepatitis B have proven effective in reducing cancer incidence, **therapeutic cancer vaccines** aim to treat existing cancer by stimulating the immune system to attack tumor cells.

Key Approaches:

- **Peptide Vaccines:** These vaccines involve the injection of synthetic peptides derived from tumor-specific antigens. The immune system recognizes these peptides as foreign and mounts a targeted immune response.
- **Dendritic Cell Vaccines:** These vaccines use a patient's dendritic cells (which are key in antigen presentation) to prime the immune system against specific tumor antigens. Dendritic cells are isolated from the patient's blood, exposed to tumor antigens, and then re-infused into the patient.
- **DNA/RNA Vaccines:** These vaccines deliver the genetic material encoding a tumor antigen directly into the patient's cells, which then produce the antigen and stimulate an immune response.

Such as, Sipuleucel-T is an FDA-approved **dendritic cell vaccine** for metastatic prostate cancer. It has demonstrated modest improvements in survival and represents one of the first approved cancer vaccines for therapeutic use.

Challenges and Future Directions in Cancer Vaccine Development

Despite promising advances, the development of effective therapeutic cancer vaccines has faced several hurdles:

- **Tumor Antigen Heterogeneity:** The presence of diverse antigens in different tumor cells complicates the development of a universal vaccine.
- **Immunosuppressive Tumor Microenvironment:** The tumor microenvironment is often hostile to immune responses, with immune checkpoint pathways such as PD-1 and CTLA-4 preventing the immune system from mounting an effective attack.
- **Long-Term Immunity:** Achieving long-term immunity with cancer vaccines remains a challenge, as the immune system can sometimes fail to maintain a response after the initial treatment.

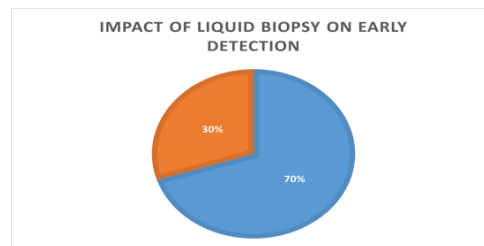
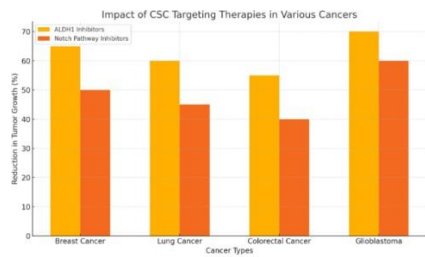
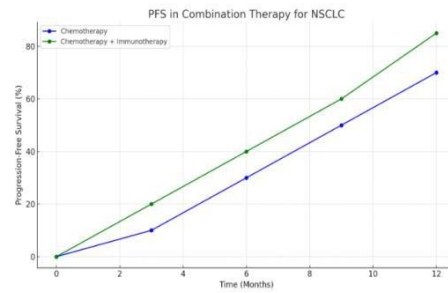
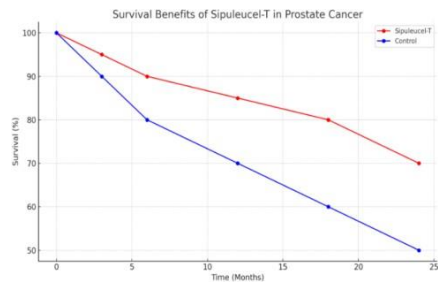
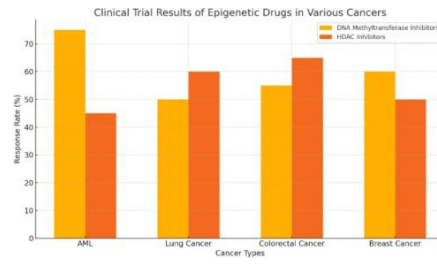
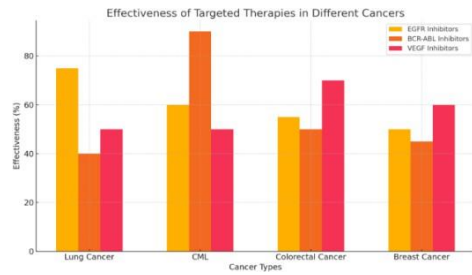
Future efforts will focus on overcoming these barriers by developing combination therapies that integrate vaccines with immune checkpoint inhibitors and other immune-modulatory agents.

The landscape of cancer treatment has evolved significantly, from traditional approaches like surgery and chemotherapy to personalized therapies, immunotherapies, and gene-editing techniques. With the advancement of technologies such as artificial intelligence, liquid biopsy, and CRISPR, we are entering a new era in which cancer can be managed with increasing precision and efficacy.

Key challenges remain, including overcoming drug resistance, improving patient access to cutting-edge treatments, and addressing the complexity of tumor heterogeneity. However, with continued research, collaboration, and the integration of emerging technologies, the fight against cancer will only become more robust.

The future of cancer treatment lies in the seamless integration of targeted therapies, immunotherapy, personalized medicine, and technological innovations to ensure that all patients, regardless of their cancer type, receive the most effective and tailored treatments. As we continue to unlock the mysteries of cancer biology, we move closer to a world where cancer is no longer an insurmountable challenge but a treatable and, ultimately, curable disease.

Appendix 1: Graphs representing data from section 2-5



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An Exploratory Study of Employee Perceptions: Assessing the Efficacy of Devaswom Board Governance in Kerala Temples

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Abstract

In this study, Kerala's Devaswom Boards, a system of governance of temples, and their intricacies are examined, and the employee perspective is taken to understand leadership communication, empowerment, and organizational loyalty in temple management. In particular, this study examines how employee empowerment mediates the relationship between leadership communication and organizational loyalty, showing how empowerment is key to a committed workforce. It further investigates the moderating role of workplace hierarchy on the impact of leadership communication on employee empowerment by taking into account the Devaswom Board's layered organizational structure. A total of 300 employees, 100 employees from each of the Cochin, Travancore, and Malabar Devaswom Boards, were recruited to obtain a complete picture of Kerala's temple governance ecosystem. Structural Equation Modelling (SEM) was then applied to analyse the reams of data to unravel the complex interplay of variables and uncover robust statistical insights. The study findings seek to shed some light for their policymakers and Devaswom Board administrators on the significance of open leadership communication and the effects of this on empowerment and loyalty through the levels of the hierarchy. The study also reveals that improvements in leadership communication significantly boost employee empowerment. Organizational loyalty is positively impacted by shifts in employee empowerment also greatly enhanced by changes in leadership communication. Enhancing employee empowerment is the primary way that effective leadership communication affects organizational loyalty, underscoring the critical role that empowerment plays as a mediator in this interaction. The study also shows that employee empowerment is impacted by workplace hierarchy and how it interacts with leadership communication. This study contributes to the wider debate on the effective governance of religious institutions by focusing on the interplay between leadership practices and organizational dynamics. The strategies on offer are not only actionable and applicable in improving employee satisfaction and retention, but also demonstrate the importance of inclusion in boosting the operational efficiency of temple management in Kerala.

Keywords: Leadership Communication, Employee Empowerment, Organizational Loyalty, Workplace Hierarchy, Devaswom Board Temples, Organizational Behaviour

JEL Code: M12, M14, M54, L22, D23

Introduction:

Indeed, Kerala's Devaswom Boards, which govern a huge number of temples in the state, find themselves with the unenviable task of preserving culture and simultaneously governing temples competently. Not just as custodians of religious and cultural values but also as important employers, these boards have their own staff composed of priests, administrative staff, and maintenance men. Leadership communication on these boards is of paramount importance because it directly shapes employee gratification, organizational loyalty, and overall effectiveness (Cooper et al., 1997). In hierarchical organizations, such as Devaswom Boards, where empowerment is central to achieving a motivated workforce, communication plays an extremely important role. However, this process is often hindered by hierarchical constraints, which create challenges that require active intervention (Heuss & Datta, 2023). This thesis addresses the relationship between leadership communication, employee empowerment, and organizational loyalty to provide actionable insights for improved governance.

Organizational dynamics in religious institutions research illustrates the unique difficulties resulting from the cultural and hierarchical nature of their structures. In such organizations, employees rarely obtain upward mobility opportunities, which is why the empowerment of employees with effective leadership communication becomes even more vital (Lin et al., 2022). Additionally, workplace hierarchy can also moderate the impact of leadership communication, facilitating or restricting the ability of leadership communication to drive employee

empowerment (Bouma et al., 2023). Prior studies have also found an increase in organizational loyalty among empowered employees, with processional outcomes on the institution increasing (Ahmed et al., 2023). However, little empirical research exists on these dynamics within the framework of temple governance in Kerala. Bridging this gap, this study examines the mediation effect of employee empowerment and the moderating effect of workplace hierarchy in relation to leadership communication and the consequent contribution to improving governance practices pertaining to Devaswom Boards.

Statement of the Problem

This study aims to address the problem of inadequate understanding of the manner in which leadership communication affects employee empowerment and organizational loyalty in the case of Devaswom Board temples in Kerala. Previous research has examined leadership communication and employee empowerment in other organizational contexts (Ashkanasy et al., 2021; Jose & Mampilly, 2015), but this is not the focus of this aspect. Furthermore, although there is a clear understanding of how employee empowerment mediates the connection between leadership communication and organizational loyalty in corporate contexts (Gorde et al., 2022), its application in temple settings has not yet been established. Moreover, the effect of workplace hierarchy has not been adequately explored in these relationships, especially in organizations with a tightly structured hierarchy of workers, such as temples (Cochran & David, 1986). An inquiry into how leadership communication shapes empowerment, organizational loyalty, and its relationship with workplace hierarchy in temple organizations is needed to fill this gap in the literature. Closing these gaps will fill in the missing pieces to improve performance of employee engagement and governance in Devaswom Board temples, where leadership practices are key to achieving operational effectiveness as well as employees' commitments to the temple ((Ennis et al., 2018); (Ahmed et al., 2023).

Literature Reviews and Hypotheses Development

An intimate relational connection has been made between leadership communication and employee empowerment as a key to creating and maintaining a productive organizational environment. Communication is an effective leadership tool; it clarifies, builds trust, and aligns objectives that empower employees to feel they can accomplish more in their roles (Ashkanasy et al., 2021). The role of leadership communication is even more pronounced in Devaswom Board temples, which are not only based on cultural and hierarchical constraints, but the processing of such a set of conditions poses a greater challenge to its communication. According to previous studies, more empowered employees give more to the organization and are more capable of easily contributing to an organization's goals, which can be achieved through transparent and consistent communication by leaders (Kanjanakan et al., 2023). Empowered employees tend to exhibit higher levels of organizational loyalty if empowerment is a trigger for a feeling of belonging to the institution (Jose & Mampilly, 2015). This is essential for both operational efficiency in temple settings and conservation of cultural heritage.

In addition, leadership communication directly impacts organizational loyalty, as employees usually regard open communication as a symbol of trust and respect (Gorde et al., 2022). Moreover, employee empowerment acts as a mediator between leadership communication and organizational loyalty, meaning that communication alone is not effective without the practice of empowerment (Ennis et al., 2018). Nevertheless, the effect of leadership communication on empowerment is not the same at all hierarchical levels. This relationship is moderated by workplace hierarchy, with the effects of different communication practices depending on employees' hierarchical positions (Cochran & David, 1986). This dynamic in Devaswom Board temples necessitates leadership strategies that accommodate hierarchical nuances as well as opening ways to empower in order to effectively improve organizational loyalty.

H1: Leadership Communication Positively Influences Employee Empowerment in Devaswom Board Temples.

It is well known in leadership communication that employee empowerment is fostered on the basis of a foundation of employee empowerment, especially in culturally diversified, but hierarchically structured organizations such as Devaswom Board temples. Leadership communication, for it to be effective, includes clarity, transparency, and constant engagement with each other, which ultimately creates an atmosphere in which empowerment and accountability can thrive (Ashkanasy et al., 2021). Communication from leaders in religious institutions, where formal hierarchies reign supreme, has been shown to be of practical use in closing the distance between organizational objectives and employee autonomy (Kanjanakan et al., 2023). Employees who work with leaders who communicate openly and provide prompt feedback are better able to develop self-efficacy and make decisions on their own (Gorde et al., 2022). With regard to temple management, however, which is characterized by the tradition of not involving employees in decision-making, as happens in the specific temple context studied, leadership communication can breach the existing barriers to communicating inclusion and autonomy (Lin et al., 2022). Communication of vision and clarity of expectations have also been seen to help leaders empower employees by helping them understand their roles and boost their confidence in

taking initiative (Chikazhe & Nyakunuwa, 2022). In addition, leader communication that is sensitive to culture in contexts such as Devaswom boards also strengthens employees' connections with organizational values while also empowering them (Ennis et al., 2018). Having a positive influence in such situations is extremely important to the organization, especially in traditional organizations where the outcome of their empowerment initiative is dependent largely on the quality and frequency of leadership communication (Cochran & David, 1986).

H2: Employee Empowerment Enhances Organizational Loyalty Among Employees In The Temple Setting.

Employee empowerment is one of the most important determinants of organizational loyalty, especially in culturally important settings, such as temples, where employees struggle with rigid hierarchies and conventional restraints. Initiatives for empowerment, which increase employees' autonomy, competence, and sense of belonging, are shown to immediately affect their commitment to organizational goals (Chikazhe & Nyakunuwa, 2022). Empowered employees feel like they are part of achieving organizational success and, as a result, are influenced by increasing job satisfaction and emotional attachment (Gorde et al., 2022). Empowerment in religious institutions, such as temples, which fundamentally deal with the cultural values of work, helps employees map their personal and organizational values and, hence, their loyalty (Kanjanakan et al., 2023). Through the practice of empowering workers, such as participative decision making and ensuring that employees have access to the required resources, employers earn the trust of their employees and management by treating them with the respect they deserve, thus increasing loyalty in employees (Ennis et al., 2018). In addition, research indicates that empowered employees are more resilient to challenges at work and demonstrate behaviours that benefit the organization over the long term, building long-term loyalty (Lin et al., 2022). This is especially important in the temple context because job roles are often traditional and less dynamic, which is why empowerment is an essential strategy to raise employee engagement and loyalty (Cochran & David, 1986). On the other hand, employee empowerment leads to the creation of a dedicated and loyal workforce by fostering a sense of ownership and accountability (Ahmed et al., 2023).

H3: Leadership Communication Positively Impacts Organizational Loyalty Among Temple Employees.

Leadership communication is a key organizational driver of loyalty, particularly in temples, which are seen as traditional and culturally saturated environments. The trust, clarity, and alignment between what the organization seeks to achieve and what its employees can realistically be expected to provide is also predicated on effective communication by leaders (Ashkanasy et al., 2021). Leaders need to communicate transparently and consistently, so employees feel they have a sense of belonging and stay committed to the organization (Gorde et al., 2022). Leadership communication, for example, assumes a critical role in temple settings (Kanjanakan et al., 2023), where employees typically work within hierarchically structured environments and have to address employees' concerns and enable alignment of individual efforts towards organizational values. According to research, leadership communication not only helps employees understand their role in a company but also their emotional connection to the firm increases as their loyalty increases (Ennis et al., 2018). Moreover, empathetic communication practices, which are sensitive to the cultural and emotional needs of employees, have been found to enable a good operational environment that promotes sustained loyalty (Chikazhe & Nyakunuwa, 2022). Effective leadership communication in religious organizations where employees connect to their work is entrenched in tradition, aligned with a shared purpose, improves loyalty, and decreases turnover intentions (Cochran & David, 1986). Moreover, research shows that leaders who spend time in dialogue with attention to constructive feedback foster an atmosphere of mutual learning, which contributes greatly to fostering an atmosphere of shared respect and trust (Ahmed et al., 2023).

H4: Employee Empowerment Mediates The Relationship Between Leadership Communication And Organizational Loyalty.

There is widespread consensus that employee empowerment is a mediator in leadership communication—organizational loyalty connections. Leadership communication practising toward effective leadership communication and result in giving the empowerment of employees by knowing well, supported and enabling the employees to be empowered in their position (Chikazhe & Nyakunuwa, 2022). Empowered employees are more likely to embed organizational goals into their personal goals, resulting in even stronger loyalty (Gorde et al., 2022). Ashkanasy et al. (2021) found that research indicates that effective leader communication (transparency, feedback and active listening) results in improved employee perceptions of being valued and trusted and directly contribute to their empowerment. Such empowerment is a conduit that translates the positive leadership communication effects into stronger organizational loyalty (Lin et al., 2022); in temple organizations, where the hierarchical structure impedes employee autonomy, leadership communication directing inclusivity, and participatory decision-making helps facilitate employee empowerment (Kanjanakan et al., 2023). Leadership's influence on employees' loyalty towards the organization has been mediated by their engagement and

commitment (Ennis et al., 2018). Studies also indicate that empowering communication practices, such as delegating and recognizing, prevent this chasm from occurring between leadership attempts and employees' emotional ties with the organization (Ahmed et al., 2023). Mediation is highly important in culturally organized institutions, where communication and empowering strategies are effective in changing organizational dynamics and perpetuating employee loyalty (Cochran & David, 1986).

H5: Workplace Hierarchy Moderates the Relationship between Leadership Communication and Employee Empowerment, With the Effect Varying Based On the Level of Hierarchy

The relationship between leadership communication and employee empowerment is moderated significantly by the workplace hierarchy, depending on the hierarchical level. Communication in the leadership of a hierarchical structure is often a means through which employees feel empowered since it affects information flow, decision-making, and perceived trustworthiness (Ashkanasy et al., 2021). In rigid hierarchies, top-down communication could reduce empowerment, as those lower down may only get access to leadership and the ability to make decisions (Kanjakanan et al., 2023). However, if top leaders engage in inclusive and clear communication, hierarchical challenges can be relieved and even lower-level employees feel empowered (Cochran & David, 1986). On the contrary, a flatter structural organization with least rigid hierarchies is more likely to encourage more direct and participative communication, which leads to a high rate of empowerment across all levels of the organization (Ennis et al., 2018). Research has shown that employees in higher positions in the hierarchy often feel more empowered because they are closer to leadership and have greater access to critical information that makes them appear knowledgeable about ways of creating alternative strategies (Gorde et al., 2022). Hierarchical roles have a moderating effect that is more visible in traditional settings, such as temples, where cultural and structural dynamics work for or against the impact of leadership communication on empowerment (2019). Promoting open-door policies, enabling equitable decision-making, has been found to increase empowerment at all levels of the organization if it directly addresses hierarchical constraints (Ahmed et al., 2023). These findings point to the complex nature of the leadership empowerment relationship and its dependence on issues of workplace hierarchy in organizational settings.

Research Gap And Research Questions

Despite the abundance of research on individual aspects of leadership communication, employee empowerment, and organizational loyalty, little knowledge exists about the interplay of these concepts in the context of religious and culturally based organizations such as Devaswom Board temples in Kerala. Most research centers on broadly distributed organizational environments (Ashkanasy et al. 2021; (Chikazhe & Nyakunuwa, 2022)), while lacking attention paid to how leadership communication is related to employee empowerment and organizational loyalty in settings based on temples (Kanjakanan et al., 2023). Although the mediating role of employee empowerment on organizational behaviour is well documented (Gorde et al., 2022), its particular influence within religious institutions has not been studied. Additionally, little attention has been paid to the influence of workplace hierarchy (as a moderating factor in these relationships), especially in culturally hierarchical settings, as found in temples (Cochran & David, 1986). Past research in corporate sectors (Ennis et al., 2018) has stressed the role of leadership communication and empowerment in organizations; however, few studies have been conducted to consider both these variables in the peculiar organizational system of religious institutions. For this reason, this research attempts to fill these gaps by exploring how leadership communication is linked to employee empowerment and organizational loyalty in a temple setting, considering how workplace hierarchy moderates these relationships, and hence suggests ways to enhance governance and employee involvement in Devaswom Board temples.

The research questions attempt to find the interfaces between leadership communication, employee empowerment, and organizational loyalty in the case of Devaswom Board temples. The study starts by examining how leadership communication impacts employee empowerment inasmuch as effective communication is understood to increase employees' perception of autonomy in and participation in decision-making, thereby fostering empowerment (Ashkanasy et al., 2021; (Jose & Mampilly, 2015)). Second, the relationship between employee empowerment and organizational loyalty is explored, and employee empowerment is positively related to organizational loyalty due to a sense of responsibility and being recognized for the job (Gorde et al., 2022). Third, this study seeks to analyse how leadership communication influences organizational loyalty among temple employees, as good leadership communication with employees is powerfully conducive to developing employees' emotional attachment to work organizations (Ennis et al., 2018). The fourth research question investigates whether employee empowerment mediates the relationship between leadership communication and organizational loyalty, which is confirmed by studies that demonstrate that empowerment is a catalyst for converting leadership communication into increased loyalty (Ahmed et al., 2023). Finally, the study discusses the moderating role of workplace hierarchy in the relationship between leadership communication and employee empowerment, in that hierarchy can either limit or amplify the effects

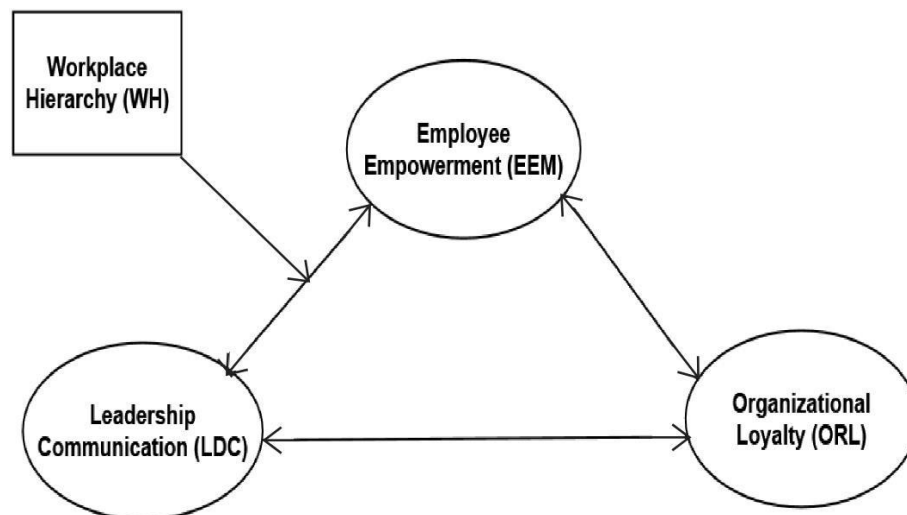
of leadership communication depending on where employees are in that hierarchy (Cochran & David, 1986). Collectively, the questions centered on what leadership practices and organizational structures affected employee outcomes in the temple setting.

Conceptual Framework

This study adopts a conceptual framework to analyse the relationships prevalent between leadership communication, employee empowerment, workplace hierarchy, and organizational loyalty while studying the context of leadership communication in the temples of the Devaswom board under Kerala. It also hypothesizes that leadership communication is the driving force behind employee empowerment, which then influences organizational commitment. This communication creates an empowerment sensation by giving employees a sense of autonomy, responsibility, and acknowledgment of what they can easily do in their roles (Chikazhe & Nyakunuwa, 2022). The magnitude of the influence between leadership communication and organizational loyalty can be mediated by employee empowerment, which is defined as the degree to which employees feel they have control over their work and decision-making processes (Gorde et al., 2022). Surveys show that empowered employees are more emotionally tied to the organization and less likely to change jobs, which creates loyalty (Ennis et al., 2018).

Moreover, these relationships are moderated by workplace hierarchy, which affects the strength of the relationships among leadership communication, employee empowerment, and their effect on organizational effectiveness. Communication from leadership in settings dominated by hierarchical organizations, such as temples where power and decision making are condensed to upper levels of the hierarchy, is likely to have a greater impact on empowerment at the higher levels of the hierarchy (Kanjakanan et al., 2023). Although employees at lower levels of hierarchy may not have access to leadership and suffer from limited types of empowerments, the positive effects of leadership communication will be reduced (Cochran & David, 1986). The moderating role of workplace hierarchy indicates that organizations with flatter structures or more inclusive leadership communication practices will have higher empowerment across all levels (Ahmed et al., 2023). The conceptual framework then shows how leadership communication influences employee empowerment and organizational loyalty, while the workplace hierarchy moderates these phenomena.

Figure 1: Employee Empowerment Model for Devaswom Board temples



Source – Author's Own Framework

Objectives of the Study:

- To examine how employee empowerment mediates the relationship between leadership communication and organizational loyalty in Devaswom Board temples in Kerala.
- To explore how workplace hierarchy moderates the impact of leadership communication on employee empowerment in Devaswom Board temples in Kerala.

Methodology and Research Design:

This study investigates the linkages between Devaswom Board temples in Kerala leadership communication, employee empowerment, and organizational loyalty. In terms of research design, a descriptive causal approach was adopted, whereby a systematic analysis of the causal relationships among variables was performed using a Structural Equation Modeling (SEM).

Research Design

To understand how leadership communication affects employee empowerment and organizational loyalty as well as how these relationships are mediated and moderated, this study employs a descriptive-causal study design. The causal nature of the research allows for the examination of how leaders practise in the context of the temple organization may impact employee outcomes (e.g., empowerment and loyalty) as well as understanding how the structure of hierarchy impacts the effectiveness of leader practices. This work allows for the testing of the hypothesized relationships proposed in the study's conceptual framework. The data collection period was from August 2024 through November 2024.

Sample and Sampling

The study focuses on a sample of 300 employees from three major Devaswom Boards in Kerala: These Cochin Devaswom Board, Travancore Devaswom Board, and Malabar Devaswom Board. Each board had three boards and 100 employees. To examine the moderating role of workplace hierarchy, employees were selected from different hierarchical levels in these organizations.

This study uses a stratified random sampling technique, which is best suited to ensure that employees are at different levels within the organization (operational and administrative staff are represented in the sample). Random sampling by stratum splits the population into separate subgroups or strata (i.e., hierarchical levels within each Devaswom Board), and randomly chooses members of the sample from each stratum. The benefit of this method is that it ensures that the sample is representative of the whole population, especially in hierarchical representation, which is one of the most important elements in analysing the moderating role of workplace hierarchy in the leadership communication – employee empowerment relationship.

Furthermore, the stratified sampling technique ensures adequate representation of employees from each board, and the sample is a true reflection of the diversity in the organization. Using Structural Equation Modelling (SEM), a final sample size of 300 employees was sufficient, as SEM typically recommends a minimum of approximately 200-300 employees to produce accurate and valid results (Kline, 2015). Through this technique, it was possible to effectively test the hypothesized relationships between leadership communication, employee empowerment, organizational loyalty, and the moderating effect of workplace hierarchy.

Tools and Techniques

The primary data collection tool used in this study was a structured questionnaire. By involving items related to leadership communication, employee empowerment, organizational loyalty, and workplace hierarchy, the questionnaire helps assess the company's efficiency in communication. The scales used to measure leadership communication are based on the leadership communication literature (Ashkanasy et al., 2021), and the scales for employee empowerment are adapted from empowerment studies (Gorde et al., 2022). Loyalty scales are used, which are commonly used in research on organizational behaviour (Chikazhe & Nyakunuwa, 2022) to measure organizational loyalty. An organization's structure is categorized by its positions in the workplace hierarchy.

Structural equation Modelling (SEM) was used for Data Analysis through the use of AMOS 26 software. SEM also allows us to analyse more complex types of path relationships, such as mediation and moderation effects. The measurement model was validated using confirmatory factor analysis (CFA). The relationships between the latent constructs (leadership communication, employee empowerment, and organizational loyalty) were tested using path analysis.

Results and Discussions

Table 1: Demographic Profile of Devaswom Employees

Gender	No. of Employees	Percent
Male	181	60.3
Female	119	39.7
Total	300	100.0
Age	No. of Employees	Percent
Below 45	22	7.3
45-50	110	36.7
50-55	97	32.3
Above 55	71	23.7
Total	300	100.0
Marital Status	No. of Employees	Percent
Single	94	31.3
Married	206	68.7
Total	300	100.0
Designation	No. of Employees	Percent
Administrative	180	60.0
Operating	120	40.0
Total	300	100.0
Qualification	No. of Employees	Percent
Below SSLC	24	8.0
SSLC	93	31.0
Higher Secondary	94	31.3
Graduation	59	19.7
Post Graduation	30	10.0
Total	300	100.0

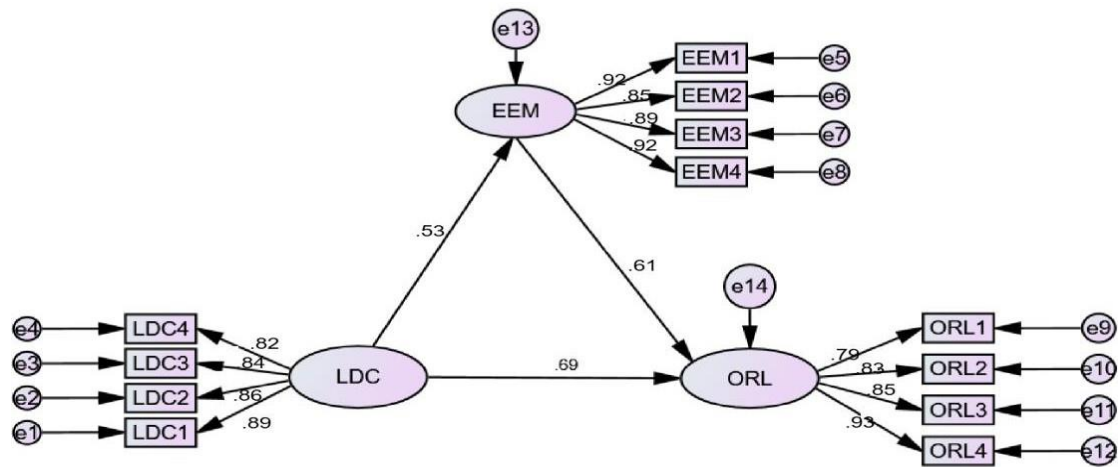
Source – Author's Own Compilation

The table 1 provides a demographic overview of the 300 employees surveyed in the study. In terms of gender, 60.3% are male, and 39.7% are female. Regarding age distribution, the majority fall between 45-50 years (36.7%), followed by those aged 50-55 years (32.3%), above 55 years (23.7%), and below 45 years (7.3%). Most employees are married (68.7%), with single employees accounting for 31.3%. In terms of designation, 60% work in administrative roles, while 40% are in operating roles. When examining educational qualifications, 31.3% have completed higher secondary education, followed closely by SSLC holders (31.0%). Graduation and post-graduation levels account for 19.7% and 10%, respectively, while 8% have qualifications below SSLC. This demographic breakdown highlights the workforce's composition in terms of gender, age, marital status, roles, and educational background.

Model Validity and Reliability

In Structural Equation Modelling (SEM), Model validity and reliability are assessed with composite reliability, convergent validity and discriminant validity. Composite reliability (CR), and values greater than 0.7 are considered acceptable (Hair et al., 2019). This is the Convergent validity, which is checked by AVE and the degree of variance of the ideal items included in the construct; thus, items aggregated to a construct that have correlation of 0.5 or more will be well correlated to share a common variance (Fornell & Larcker, 1981). Model reliability and validity can be checked with simultaneous use of both the Fornell-Larcker criterion and the discriminant validity (Henseler et al., 2015) measures and these in conjunction offer a thorough verification of robust results from the robust SEM.

Figure 2: Structured Model of Employee Empowerment Model for Devaswom Board temples



Source – Author's Own Framework

Table 2: Composite Reliability and Convergent Validity of the Employee Empowerment Model for Devaswom Board temples

	CR	AVE	MSV	MaxR(H)
LDC	0.915	0.730	0.414	0.921
EEM	0.941	0.800	0.436	0.951
ORL	0.914	0.727	0.533	0.934

Source: Author's own Compilation

An assessment of the composite reliability (CR), average variance extracted (AVE), mean shared variance (MSV), and MaxR(H) maximum shared variance for the variables of the model's of Leadership Communication (LDC), Employee Empowerment (EEM) and Organizational Loyalty (ORL) are provided in table 2. Internal consistency of the items measuring each construct was sustained (the composite reliability values span the range of 0.914 to 0.941). The values of AVE, which range from 0.727 to 0.800, indicate that indicators can sufficiently explain variances of variables with a little available measurement error. Good convergent validity is such a figure. We observe a large MSV range across these factors, from 0.414 to 0.533, which suggests that a large chunk of the variance of each construct is accounted for by factors that do not load onto any other constructs' common factors. The 0.921 to 0.951 MaxR(H) explain that constructs are discriminant in that the squared correlations are less than the communality between constructs and indicators due to the indicators being significantly related to the constructs rather than vice versa. The findings of the study indicate that the model employed has fulfilled all the necessary conditions for validity and reliability, which provide reasons for assuming that model is formally reflecting constructs.

Table 3: Discriminant Validity of the Employee Empowerment Model for Devaswom Board temples

	LDC	EEM	ORL
LDC	0.854		
EEM	0.589	0.894	
ORL	0.627	0.649	0.852

Source: Author's own Compilation

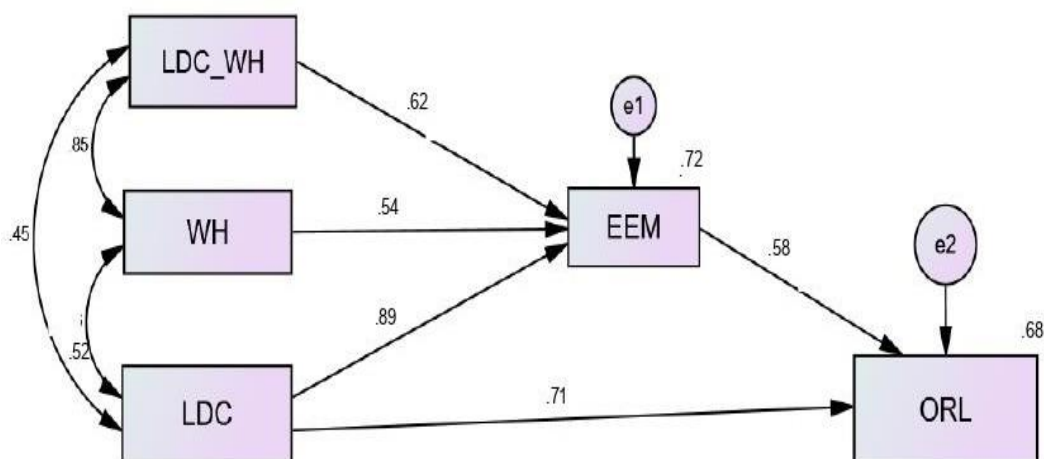
Table 3 reveals the results of the discriminant validity test for LDC, EEM, and ORL, which are the three variables involved in the model. Table's association shows squared correlations between every two variables. At the diagonal lie the scores of the AVE of each construct, and the off-diagonals confirm the squared correlation between constructs. The values of the diagonals are larger in magnitude than those on the cross-diagonals. This shows that each construct shares more statistically with its indicators than do the indicators of the others. It

contributes to the discriminant validity of the model through the division of language constructs into isolated components. Squared correlation numbers are from as low as 0.589 (which translates into 58.9% of shared variance) to 0.649 (which is more than 64.9% of shared variance), confirming that each construct is different internally. In sum, the mentioned results demonstrate that the model's factors have appropriate discriminate validity needed for different measurements.

Moderated Mediation Model

In this model (Figure 3) it adopts a moderated mediation model to examine the interplay between Leadership Communication (LDC), Employee Empowerment (EEM), organizational loyalty (ORL), and Workplace Hierarchy (WH). Leadership communication is seen as effective communication that empowers employees to increase organizational loyalty. Furthermore, Workplace Hierarchy (WH) serves as the moderating variable following the relationship between leadership communication and employee empowerment, whereby the variable moderating variable (LDC_WH) is the interaction between the two variables. The model tests the hypothesized relationships with an iteration number 5,000 as suggested by Preacher and Hayes (2008), using the bootstrapping method. Bootstrapping provides confidence intervals for indirect and moderated effects, with greater robustness to non-normality in the sampling distribution. Integrating moderation, mediation, and bootstrapping, the model presents a nuanced and statistically robust bottom line on how leadership communication and a harmonious job environment impact loyalty and how to use it to increase organizational attachment.

Figure 3: Moderated Mediation of Employee Empowerment Model for Devaswom Board temples



Source – Author's Own Framework

Model Fit:

For the SEM, model fit examination is highlighted as it would help to determine if a given theoretical framework is capable of explaining the data given. First has to be building up the foundation of how their construct dimensions impact their items. We conduct a "construct validity" on the dimensions of the relationship between Leadership Communication (LDC), Employee Empowerment (EEM), Workplace Hierarchy (WH) and Organizational Loyalty (ORL) as part of Figure 3. The values determine the model's worthiness of the data defined in Table 4.

Table 4: Model Fit Measures related to the Employee Empowerment Model for Devaswom Board temples

Model Fit Indices	Citation	Threshold Limit	Estimated Value	Interpretation
Normed Chi-Square	Kline, R. B. (2015), Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003)	< 3	59.173/28- CMIN/DF = 2.113	Excellent
CFI	Hu, L. T., & Bentler, P. M. (1999), Marsh, H. W., Hau, K. T., & Wen, Z. (2004)	> 0.90	0.928	Acceptable
GFI	Bentler, P. M., & Bonett, D. G. (1980), Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019)	>.90	0.911	Good
IFI	Bentler, P. M. (1990), Hooper, D., Coughlan, J., & Mullen, M. R. (2008)	>.90	0.947	Good
NFI	Kline, R. B. (2015).	>.90	0.926	Good
RMSEA	Browne, M. W., & Cudeck, R. (1993)	< 0.08	0.047	Acceptable
SRMR	Hu, L. T., & Bentler, P. M. (1999)	< 0.06	0.041	Excellent

Source: Author's own Complitation

The correct model indices are found in Table 4. In the model fit requirements, all (GFI>0.9, IFI>0.9, NFI>0.9, and CFI>0.9) are all greater than 0.9, the Goodness of Fit to Degrees of Freedom ratio is less than 3, and RMSEA < 0.08. A higher SRMR is shown to reduce the plausibility of the model. An acceptable model is one in which the RMSEA is less than 0.08, and CMIN/DF is less than 3.

Table 5: Direct Effect of Employee Empowerment Model for Devaswom Board temples

	Direct Relationship		Estimate	S.E.	C.R.	P
EEM	<---	LDC	0.942	0.178	5.292	***
ORL	<---	LDC	0.424	0.087	4.874	***
ORL	<---	EEM	0.534	0.064	8.344	***

Source: Author's own Complitation

H1: Leadership communication (LDC) positively influences employee empowerment (EEM) in Devaswom Board temples.

The hypothesis suggests that the relationship between the dependent variable EEM and the independent variable LDC is positive and strongly significant, at the 0.05 level of significance. This perfectly corresponds with the findings of the carried-out regression analysis, for which the coefficient was estimated to be 0.942 suggesting a positive relationship such that as LDC rises, EEM is expected to increase. The standard error estimate of 0.178 indicates the sort of fluctuation in the estimated coefficient; although it established the coefficient is statistically significant, there is a confidence interval when it comes to estimation. Looking at the coefficient, a t-statistic of 5.292 is derived by dividing the coefficient by the standard error. Similarly, the computed p-value of 0.000 (***) shows that this association is highly significant at most common standards of significance (commonly set at $p < 0.05$), which translates to the evidence strongly rejecting the null hypothesis. This finding suggests that changes in LDC have a considerable positive impact on EEM.

H2: Employee empowerment (EEM) enhances organizational loyalty (ORL) among employees in the temple setting.

The hypothesis suggests that the relationship between the dependent variable ORL and the independent variable EEM is positive and strongly significant, at the 0.05 level of significance. This perfectly corresponds with the findings of the carried-out regression analysis, for which the coefficient was estimated to be 0.534 suggesting a positive relationship such that as EEM rises, ORL is expected to increase. The standard error estimate of 0.064 indicates the sort of fluctuation in the estimated coefficient; although it established the coefficient is statistically significant, there is a confidence interval when it comes to estimation. Looking at the coefficient, a t-statistic of 8.344 is derived by dividing the coefficient by the standard error. Similarly, the computed p-value of 0.000 (***) shows that this association is highly significant at most common standards of significance (commonly set

at $p < 0.05$), which translates to the evidence strongly rejecting the null hypothesis. This finding suggests that changes in EEM have a considerable positive impact on ORL.

H3: Leadership communication (LDC) positively impacts organizational loyalty (ORL) among temple employees.

The hypothesis suggests that the relationship between the dependent variable ORL and the independent variable LDC is positive and strongly significant, at the 0.05 level of significance. This perfectly corresponds with the findings of the carried-out regression analysis, for which the coefficient was estimated to be 0.424 suggesting a positive relationship such that as LDC rises, ORL is expected to increase. The standard error estimate of 0.087 indicates the sort of fluctuation in the estimated coefficient; although it established the coefficient is statistically significant, there is a confidence interval when it comes to estimation. Looking at the coefficient, a t-statistic of 4.874 is derived by dividing the coefficient by the standard error. Similarly, the computed p-value of 0.000 (***) shows that this association is highly significant at most common standards of significance (commonly set at $p < 0.05$), which translates to the evidence strongly rejecting the null hypothesis. This finding suggests that changes in LDC have a considerable positive impact on ORL.

Mediation Effect

To test the mediation effect of Employee Empowerment (EEM) on the relationship between Leadership Communication (LDC) and Organizational Loyalty (ORL), the researchers used the bootstrapping method with an iteration number of 5000 as suggested by Preacher and Hayes (2008). The given research was done at a 95% confidence level.

H4: Employee empowerment mediates the relationship between leadership communication and organizational loyalty.

Table 6: Mediation Effect of Employee Empowerment Model for Devaswom Board temples

Effect	Standardized Estimation	Un Standardized Estimate	Confidence Interval Low/High	P-value
Indirect Effect (LDC $\rightarrow$ EEM $\rightarrow$ ORL)	0.516	0.503	0.035/0.635	0.002

Source: Author's own Complitation

The table 6 provides statistical evidence supporting the hypothesis (H4) that Employee Empowerment (EEM) mediates the relationship between Leadership Communication (LDC) and Organizational Loyalty (ORL). The indirect effect of LDC on ORL through EEM is significant, with a standardized estimation of 0.516 and an unstandardized estimate of 0.503. The confidence interval (0.035 to 0.635) does not include zero, further affirming the mediation effect. Additionally, the p-value of 0.002 indicates that the observed mediation effect is statistically significant. These findings validate the hypothesis by demonstrating that effective leadership communication influences organizational loyalty primarily by enhancing employee empowerment, highlighting the crucial role of empowerment as a mediator in this relationship.

Probing Role of Workplace Hierarchy (WH) in Moderated Indirect Relationship

This study investigated the role of Workplace Hierarchy (WH) in the moderated (indirect) relationship between Leadership Communication (LDC), Employee Empowerment (EEM), and organizational loyalty (ORL). This analyses how WH affects the strength and direction of the mediating role of EEM in the LDC_ORL relationship. The study analyses the dynamics involved by examining how leadership communication can impact organizational loyalty through the conditional, that is, when, and contextual, that is, what conditions, the relationship between workplace hierarchy, and employee initiatives to enhance organizational loyalty.

H5: Workplace hierarchy moderates the relationship between leadership communication and employee empowerment, with the effect varying based on the level of hierarchy

Table 7: Direct effect of Moderation Effect of Employee Empowerment Model for Devaswom Board temples

	Direct Relationship		Estimate	S.E.	C.R.	P
EME	<---	WH	0.689	0.257	2.681	0.001
EME	<---	LDC_WH	0.523	0.126	4.151	0.004

Source: Author's own Complitation

Table 7 assesses hypothesis (H5) which states that Workplace Hierarchy (WH) moderates' leadership communication (LDC) and employee empowerment (EEM). WH had a significant direct effect on EEM, and the estimate (0.689) was positive, and statistically significant ($p = 0.001$). As with Workplace Hierarchy (WH), the interaction effect of Leadership Communication and Workplace Hierarchy (LDC_WH) also negatively influences EEM, with an estimate of 0.523 ($p=0.004$), and it also builds up statistical significance. These results indicate that, although WH and its interaction with LDC affect EEM, the effects are sufficiently strong to substantiate the hypothesis.

Table 8: Indirect Effect of Moderation Effect of Employee Empowerment Model for Devaswom Board temples

Effect	Standardized Estimation	Un Standardized Estimate	Confidence Interval Low/High.	P-value
Indirect Effect (LDC_WH $\square$ EEM $\square$ ORL)	0.362	0.279	.017/0.430	0.003

Source: Author's own Complitation

EEM was also used to assess the indirect effect of the interaction between Leadership Communication and Workplace Hierarchy (LDC_WH) on organizational loyalty (ORL), as shown in Table 8. The standardized estimate of the indirect effect is 0.362, with an unstandardized estimate of 0.279, upper confidence limit (UL) of 0.430, and lower confidence limit (LL) of 0.017. However, with a p-value of 0.003, the effect was statistically significant ($p = 0.003$). The findings indicate that although an indirect effect does exist, this indirect effect is moderated by Workplace Hierarchy (WH), as hypothesized. Thus, we investigated the relationship between Leadership Communication and Employee Empowerment at different levels of hierarchy and found variation in this relationship based on the level of hierarchy, supporting the moderating effect of WH on the indirect relationship.

Findings and Theoretical Implications

The findings of this study provide important insights into leadership communication, staff empowerment, organizational loyalty, and the hierarchy of workplace relationships in Devaswom Board temples in Kerala. First, leadership communication was found to have a positive influence on employee empowerment, in which employee empowerment is driven by clear and transparent communication from leaders to their employees. Empowering employees in this manner reciprocally greatly increases organizational loyalty, since employees who feel empowered are typically more dedicated to the organization's objectives and values. Additionally, the investigation establishes a direct positive leadership communication impact on organizational loyalty, indicating that good communication can improve employee trust and loyalty. Furthermore, employee empowerment mediates the relationship between leadership communication and organizational loyalty, indicating that empowered employees serve as a connecting link that intensifies the connection between leadership and organizational commitment. Additionally, this study shows that the interaction of leadership communication with employee empowerment is moderated by workplace hierarchy such that the effect of leadership communication on empowerment is stronger at lower hierarchical ranks than at higher ranks. This suggests that employees with lower hierarchical positions are more likely to be empowered through leadership communication, while employees with higher hierarchical positions may begin to disengage because of power relationships and organizational norms. The results show that effective leadership communication is key to the empowerment of employees and to fostering job loyalty in the temple settings of Kerala, and furthermore, how workplace hierarchy impacts this relationship.

This research has wider theoretical implications for understanding leadership communication, employee empowerment, and organizational loyalty in hierarchical organizations, such as the Devaswom Board temples in Kerala. This research extends the existing leadership communication theories by illustrating how good communication not only promotes employee empowerment but also boosts organizational loyalty within a religious or culture attachment-based organizational context. This research adds to the Social Exchange Theory by stressing the mediating role of employee empowerment, which shows that empowered employees are more likely to respond with loyalty, thus reinforcing the mutual nature of leader—employee interaction. In addition, the study supports and enriches empowerment theory by showing how leadership communication can be a source of employee empowerment and by addressing the subtle implications of the workplace hierarchy. This demonstrates that leadership communication is significantly influenced by hierarchical levels, in coherence with power distance and organizational structure theories. Empowerment initiatives are likely to be more effective at some levels of the workplace hierarchy than at others; workplace hierarchy moderates the effect of empowerment. The contribution of this research is to provide new theoretical insight into how leadership practices, aligned with the empowerment of employees, can positively influence the performance of an

organization in contexts where organizational practice is culturally distinct and preserved, as is the case in churches where traditional organizational dynamics are more prevalent. In sum, these theoretical contributions provide fruitful directions for future research on leadership communication in similarly hierarchical and culturally rich environments and similar efforts to empower employees.

Recommendation to the Policy Makers:

Given that this research has shown, it is therefore recommended that Policy Makers in Devaswom Boards and similar hierarchical organizations pay attention to putting clear, transparent, and inclusive leadership communication strategies in place that help with empowering employees to contribute ideas and suggestions on decisions made across various levels of the organization. Leadership training programs that develop communication skills and enhance the effectiveness of communication among senior leaders, and promote such skills and effectiveness in articulating organizational goals, values, and expectations to employees, especially those in low hierarchical positions, should be implemented by policymakers. Finally, the fact that empowerment is moderated by workplace hierarchy requires that empowerment initiatives be differentiated across hierarchical levels, with support targeted for lower hierarchical level individuals, who may derive the greatest benefit from leadership communication. Moreover, policymakers should urge the mandating of formal channels through which leaders can provide and receive feedback and speak with members of the workforce so that leaders and employees engage in a reciprocal flow of trust and loyalty. To increase organizational loyalty, empowerment strategies should be combined with organizational policies to ensure that employees feel valued and respected. Furthermore, it is imperative that the organization adopt policies that encourage the creation of equal opportunities for all employees, regardless of the hierarchical position to which they hold stakeholders. Policymakers can make Devaswom Boards' organizational culture stronger, make employees happier, and make everything better for the Devaswom Boards by aligning leadership communication with empowerment initiatives, while taking care to respect the cultural and organizational dynamics of religious institutions.

Further Scope of Study

The scope for further research based on this study is extensive, particularly in exploring the dynamics of leadership communication, employee empowerment, and organizational loyalty in other culturally significant and hierarchical institutions beyond Devaswom Boards. Future studies should investigate the influence of cultural diversity and regional variations on the effectiveness of leadership communication strategies in empowering employees. Additionally, longitudinal studies should be conducted to understand how changes in leadership styles and communication patterns over time impact employee empowerment and organizational loyalty. Further exploration of the interplay between workplace hierarchy and empowerment in different organizational contexts, such as corporate, non-profit, and public sector organisations, could provide comparative insights. The role of technology in enhancing leadership communication and employee engagement, particularly through digital communication tools, presents an avenue for further research. Expanding this study to include variables such as job satisfaction, employee retention, and organizational performance could offer a more comprehensive understanding of the outcomes of leadership practices. Moreover, examining the mediating and moderating effects of other organizational factors, such as trust, organizational justice, and cultural values, would deepen the theoretical and practical understanding. Finally, cross-country or cross-cultural comparisons of similar institutions could shed light on how sociocultural factors shape the relationships explored in this study, offering globally relevant insights into leadership and organizational behaviour.

Conclusion

Finally, this research confirms the importance of leadership communication for the empowerment of employees and organizational loyalty in Kerala's Devaswom Board temples. The results show that leadership communication significantly affects employee empowerment, and once employees are empowered, organizational loyalty escalates, and they are more committed to the organization. The results show that employee empowerment plays a crucial mediating role in linking leadership communication to organizational loyalty, thereby deepening our understanding of how communication practices influence employee attitudes and behaviors. Additionally, we show that leadership communication regarding emotions has a moderating effect on the workplace hierarchy, demonstrating that the degree to which leadership communication leads to employee empowerment varies across different levels of hierarchy, calling for context-sensitive leadership strategies. Based on these findings, these results have significant implications for both organizational theory and real-world (physically) hierarchical and culturally significant organizations (e.g., temples) where clear communication, empowering methods, and understanding of hierarchy dynamics are needed to increase organizational loyalty. This study adds to the growing literature on leadership communication and employee behaviour in non-traditional organizational contexts and provides avenues for further investigation of the variables that drive employee outcomes in these unique settings.

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Understanding Brand Love in Luxury Brand Gadgets and Accessories: Mediating Role of Electronic Word of Mouth in the area Delhi and NCR

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Abstract

The conception and development of Brand love (BL) has increased as consumers have started exhibiting their emotional bonds with their choice of brands. This study examines brand trust (BT) as an important factor of brand love (BL), and brand loyalty (BLT) and positive electronic word of mouth as outcomes in the Luxury Brand gadgets and accessories. Based on 250 customers' responses to a survey questionnaire circulated through google form in the area of Delhi and NCR. The respondents were from age group of 18 years to 35 years and the majority of them were from the age group of 22 years to 25 years. The respondents were the owners of Apple, Samsung, Google pixel Gadgets and Accessories. 69 percent of respondents were male and rests were female. Using a structured questionnaire, the proposed model of the study was measured and evaluated. Respondents were asked to rate their level of BT, BL, BLT, and electronic word of mouth using 25 items in the measurement scale and the hypotheses was tested. As per the findings of the study; Brand love (BL) resulted as an important antecedent of brand loyalty (BLT) and also significantly brand trust (BT). As per the mediation analysis, it has been found that electronic word of mouth has meditating effect on brand love (BL) and brand loyalty (BLT). In addition, brand love is positively allied with brand loyalty, spreading positive word-of-mouth. This research contributes to the understudied connection between antecedent and outcomes of brand love and the necessity to understand the love-loyalty relationship including additional variables. The present research has used only Luxury brands in mobile/pc gadgets and accessories, which can be extended to brands from FMCG's, automobile or fashion industry. The current study has used electronic word of mouth as moderating variable which can be restructured and /or demographics can also be used to moderate the research model. Nevertheless, results of the study are restricted to Luxury brands in gadgets and accessories and generalizations should be taken judiciously.

Key words: Brand Love, Brand Trust, Brand Loyalty, Electronic word of mouth, Luxury Brand Gadgets and Accessories

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Introduction

Luxury Brands have enjoyed a robust franchise retail network pan India. Possessing a Branded Gadgets and Accessories needs planning and a steady income. According to data provided by the market intelligence firm Cyber Media Research (CMR), iPhones in India recorded an impressive 22 percent growth in the first quarter of 2022 (<https://www.business-standard.com>).

The intention of brands is to develop brand loyalty (BLT) and brand trust (BT) thus leading to strong and positive associations with consumers which is also concerned matter for brand managers, marketers, academicians and researchers. (Ahuvia, 2020) revealed connection between brand love (BL) and materialism and stated that materialistic individuals tend to be more inclined and develop love for their favorite brands. Brand love (BL) significantly strengthens Brand Engagement and Brand Equity of Luxury Brands from viewpoint of users from China (Sohaib, *et al.* 2023). Brand trust (BT) is a sense of security and reliability believed in interactions of customer with brand; it is established on the view that brand is dependable, trustworthy and takes care of the interests, and wellbeing of the users (Ballester, *et al.*, 2003). Online reviews had an important positive influence on developing BT (Tran, *et al.*, 2022).

According to the Word of Mouth Marketing Association (WOMMA), purpose of WOM marketing is to give customers a motive to discuss the unique offerings of a brand and enable the conversation to occur. Brand love (BL) is found out to lead to positive WOM and eWOM (Kiuru and Katrine, 2014; Albert and Merunka 2013; Anggraeni and Rachmanita, 2015).

Consumers with high need of loyalty tend to have positive associations towards trust. This trust and gradual emotional bonding leads to BL which again make consumers to spread good word of mouth socially and digitally and become loyal. However, there is lack of empirical evidences that BL can affect BLT through mediation of electronic word of mouth (eWOM) for consumers in perspective of Luxury brand Products (Gadgets and accessories). This study addresses knowledge gap by investigating the association of BT with the BL and subsequently BL with BLT through electronic word of mouth among consumers of luxury brand gadgets and accessories. This study endeavors to answer questions such as: Is BT positively associated with BL of consumers? Is BL positively associated with BLT for consumers using luxury products? Is BL is positively related with BLT through (eWOM) electronic word of mouth for consumers using?

Literature Review and Hypothetical Framework

Brand Love (BL)

Love is always an affection which when combined with excitement can generate desire and recognition by consumers (Bayraktaroğlu, 2018; Ahuvia, 2020). BL can be defined as “the extent of emotional attachment a satisfied consumer shows towards a specific brand” (Carroll and Ahuvia, 2020; Aro *et al.*, 2018). Another research contribution postulated on BL also suggests that a consumer must have had a common history due to which they consider brand identity as integral to their own lives (Ahuvia, 2009). Nevertheless, the criticisms of this concept has also been prevalent which stipulates that BL is mere an outcome of interrelated behavioral elements rather than a feeling or emotion (Batra *et al.*, 2012; Huber *et al.*, 2015; Langner *et al.*, 2015). Yet, there are other work that presents the positive relationship between BL and interpersonal relationships. Subsequently, scholars provided numerous measurement options to measure the emotion of love such as: BT and identification, excitement, delight and consumer experience (Roy *et al.*, 2012; Albert *et al.*, 2013; Vernuccio *et al.*, 2015).

Results of study done by (Rahman, *et al.*, 2021) reflected four behavioral consequences of BL which are BLT, ready to pay extra money, spreading good word and ignoring minor brand mistakes.

Brand Trust

Trust has been discovered as cornerstone among the studies of management sciences and human psychology (Ledikwe *et al.*, 2019). The definition of BT explored by different authors in their diverse work mentions it as consumer s’ choice to believe the promises of the brand for fulfillment of specified goal (Portal *et al.*, 2018).

Although previous studies on BT have used Technology Adoption Model (TAM) to justify its dimensions of reliability linking with perceived risk for product category into technical or innovative based nature and another dimension of its supporting customers in their welfare despite an unexpected problem arise with the product is linked with TAM another characteristic which is Perceived usefulness. Further, with the addition of new dimensions to BT, other studies have explored antecedents to BT as perceived reputation and authenticity (Koufaris and Sosa, 2004; Bergstron and Zuazu, 2019).

In the current study, it is proposed to include luxury brands related and consumers’ unique point of difference related factors, thus, the trust in a hardware and software brands for their series of innovative products will be measured through consumer experience (Ha and Perks, 2005), brand communication (Notedboom, 2002) and reputation (Doney and Cannon, 1997).

Electronic Word of Mouth

The traditional WOM emerged based on the strength of interpersonal relations among family, friends and social circle. Depending on the strength or closeness among these relations, a positive or negative WOM is generated (O’reilly and Marx, 2011). The eWOM is an extension of traditional WOM where consumers’ presence on social networks such as Twitter, Instagram, Pintrest etc. and brands web pages allows them to connect, create and rely on the online reviews that help them to generate eWOMs. Companies are taking advantage of it by providing user interface option for consumers to leave comments and share opinions related to their products and services (Vallejo *et al.*, 2015). Additionally, eWOM is a gateway for businesses to understand consumer needs and preferences in a cost-effective manner and it also reduces risk of decision –making at the part of consumers (Nieto *et al.*, 2014; Hussain *et al.*, 2017; Mishra *et al.*, 2023). Many authors who have contributed to this concept have systematically built up its elements related to motivation, source and website related factors

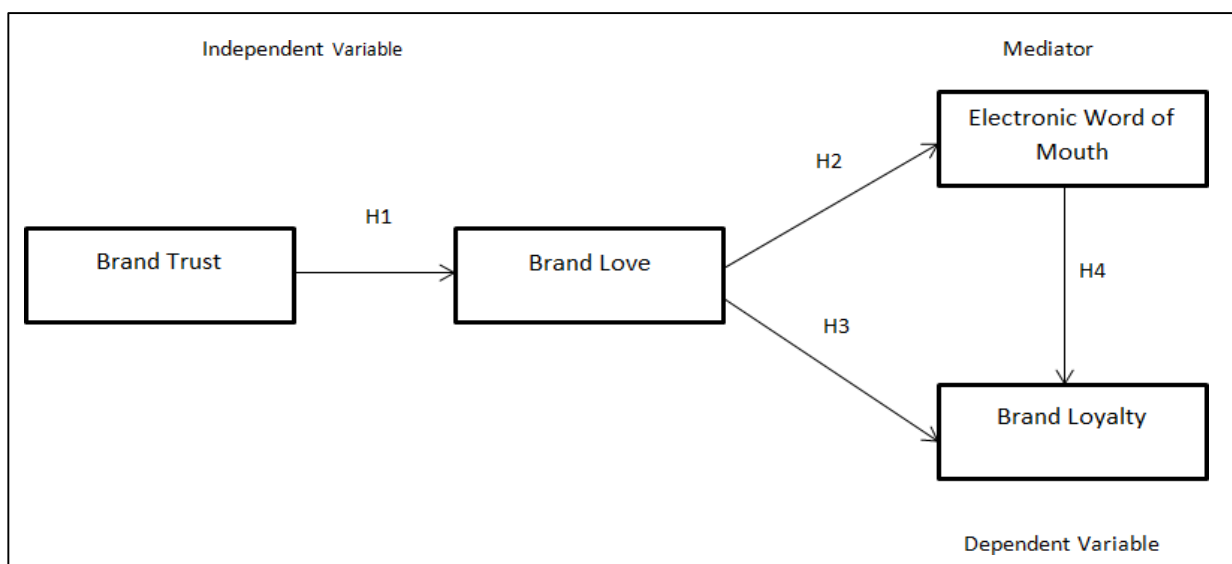
(Al-Haidari 2014; Rani and Shivaprasad, 2019). Specifically, for the luxury brands in gadgets, which has impacted technology, society and world at large, online review quality and source credibility (Carroll, et al., 2006; Aravind and Nair, 2016; Pooja and Kumar, 2021) can be important characteristics of eWOM that can affect its effectiveness.

Brand Loyalty

In any product category, BLT signifies a consumer preference. Jacoby and Chestnut (1978) defined BLT as “biased decision among alternatives out of a set of brands from a similar product category”. There have been two sides of construct in BLT one is attitudinal and the other is a behavioral. This two-dimensional approach was supported by many researchers who separated the attitude and behavior outcome to measure BLT (Dick and Basu 1994; Sharp and Wright 1999). Manufacturing companies in technology products focus more on delivering value to customer to stay ahead of competition and the relative consequence of brand experience together with relationship measure develops BLT (McDougal and Terrence, 2000; Knox and Walker, 2010; Jeb, 2014). The emphasis on BT is based on findings that BT strongly resonates with BL (Chaudhuri and Holbrook, 2001).

Hypothetical Framework

Figure 1: Theoretical Framework



Source: Authors’ proposed framework

Brand Trust and Brand Love

Brand trust is explained as “the willingness of the customer to believe and depend on the ability of the brand to perform its stated functions” (Chaudhari and Holbrook, 2001) however, it has been argued that BT and BL are two different constructs; nevertheless they are interconnected so well that they are analogous to each other (Loureiro, 2010). The two indicators of BL have found to be intersected with BT meaning that is reliability and intention (Florence, 2013). Another research added “affection” as the third indicator (Geçti1 and Zengin, 2013). Further, trust has always found close to emotional aspects thus, trust may lead to generate emotional feelings, so a positive link can be established between BT and BL. Also studies have shown that BT has a positive influence on BL, and BL influence attitudinal and behavioral loyalty (Zhang, *et al.*, 2020). Consequently, when a customer trusts the new innovative product which he/she uses, at the same time, a positive vibe and emotion can be reflected for this brand. Thus, the hypothesis can be:

H1: Brand trust is positively associated with Brand Love

Brand Love and Electronic word of mouth

Following the above arguments, Batra *et al.*, (2012) posited that BL is about emotional attachment to continuous interface with a particular brand. And if the consumers are deeply involved with the brands, they like to display affection towards it by recommending it to others (Leong *et al.*, 2020). Many researchers also consider such

customers as loyal activists for brands who actively comment and being vocal on social sites. Brand loving has a bigger role to play in motivating consumers to share positive remarks about brand to their family and community at large. Researchers in their studies have proved that BT leads to BLT and word of mouth (Liao, *et al.*, 2011; Wu, 2017) and brand love positively influences word of mouth (Albert and Merunka, 2013).

H2: Brand Love is positively associated with Electronic word of mouth

Brand Love and Brand Loyalty

BL indicates the maximum level of emotional connection of a satisfied consumer. However, researchers in the past have argued the reasonability of BL forming consumer brand relationship (Choi *et al.*, 2017; Berry *et al.*, 2002) where many authors have appropriately defined that love as a construct can be applied to consumer behavior (Batra *et al.*, 2012). As BL scales developed despite criticism on their applicability to measure interpersonal relationships, Alberta (2009) had given three outcomes of BL; good word of mouth, trust and loyalty. Further research on antecedents and consequences of BL also identified BLT as an outcome of BL as such that later apart from influencing consumer intention to purchase, affect consistent closeness towards the brand (Drennan *et al.*, 2015; Tsai, 2011). BL resulted as one of the significant antecedents of BLT and also the strongest predictor of brand equity (Nawaz, *et al.*, 2020). Drawing on that, this study thus, assumes the relationship to test for luxury Products and accessories.

H3: Brand Love is positively associated with Brand loyalty

Electronic Word Of Mouth and Brand Loyalty

Mazzarol, Sweeny and Startar (2007) study explains the Brand Loyalty as an outcome of electronic word of mouth (eWOM). Srinivasan *et al.* (2002) study reveals that behavioral results of BLT are from positive word of mouth. Balakrishnan, *et al.*, (2014) found that eWOM is positively related to BLT. In addition, satisfaction has an accumulative incremental outcome and influence on BLT. The process of BLT creation involves repurchase intention and positive word of mouth. Herdan and Heyman (2009) study found that the internet users leverage on the opportunity to contribute towards sales by showcasing brand loyalty to e-marketers. Based on the previous researches, results have shown that eWOM has an impact on BLT.

H4: Electronic word of mouth is positively associated with Brand loyalty

Research Methods

Data Sources and Variables

Using a structured questionnaire, the proposed model of the study was measured and evaluated. The study asks respondents to rate their level of BT, BL, BLT, and electronic word of mouth using 25 items in the measurement scale. To examine the BT, this study adopted seven items from (Gurvies and Korchia, 2002). BL construct was measured using eight individual items adopted from (Caroll and Ahuvia, 2006; Rodrigues and Reis, 2013; Shahid *et al.*, 2020). Electronic word of mouth was measured using four items developed by (Carroll, *et al.*, 2006). BLT construct items were taken from Carroll and Ahuvia, 2006; Rodrigues and Reis, 2013; Shahid *et al.*, 2020). With consideration for the context of the four measurement constructs, all survey items were modified. Likert scale with response on a scale of "1= (strongly disagree) to 5 = (strongly agree)" was used. The survey was written in the English language. A pretesting technique was used in order to further confirm the suitability of the questionnaire and language. Five marketing management, business management, and two language experts participated for correcting and validating the survey form.

The purpose of the pre-testing exercise was to ensure the questionnaire's comprehensiveness, language, and appropriateness as well as its content validity. The unclear and unnecessary items and phrases from several of the questions have been removed during pre-testing and minor adjustment was done to improve the quality of it.

Sampling Technique and Sample Classification

Primary data was obtained from Delhi NCR during the period between October 2022 to March 2023 using random sampling and snowball sampling among luxury brand gadgets and accessories users. Total 350 respondents were approached to fill the survey questionnaires. For the purpose of this study 250 surveys were nevertheless returned. Only 250 completed questionnaires were taken into consideration for further analysis after being briefed.

Results and Discussion

Measurement Model

Brand Trust (BT) is measured using seven statements given by Gurviez and Korchia (2002), possessing a 0.765 Cronbach's alpha, a CR of 0.965, and an AVE of 0.797. All metrics are deemed appropriate for this investigation. Table 2 also lists the mean, standard deviation, factor loadings, and standardized regression weight for each statement utilized in this investigation.

Brand Love (BL) is measured using eight statements given by Carroll and Ahuvia (2006), Rodrigues and Reis (2013), Shahid *et al.*, (2020), holding a 0.774 Cronbach's alpha, a CR of 0.975, and an AVE of 0.828. All metrics are deemed appropriate for this investigation. Table 2 also lists the mean, standard deviation, factor loadings, and standardized regression weight for each statement utilized in this investigation.

E-Word of Mouth (EWM) is measured using four statements given by Carroll, Barbara A., and AC Ahuvia (2006), having a Cronbach alpha of 0.850, a CR of 0.950, and an AVE alpha of 0.827. All metrics are deemed appropriate for this investigation. Table 2 also lists the average, standard deviation, factor loadings, and standardized regression weight for each statement utilized in this investigation.

Table 1: Statistics of Construct Item

Construct	Items	Mean	Standard deviation	Factor loading	SRW	Alpha	CR	AVE
Brand Trust (BT)	BT1	1.91	1.17	0.807	0.867	0.765	0.965	0.797
	BT2	1.86	1.22	0.822	0.886			
	BT3	2.00	1.20	0.836	0.899			
	BT4	2.07	1.21	0.745	0.898			
	BT5	2.07	1.25	0.773	0.91			
	BT6	2.06	1.24	0.779	0.909			
	BT7	2.08	1.22	0.786	0.879			
Brand Love (BL)	BL1	1.98	1.19	0.797	0.904	0.774	0.957	0.789
	BL2	1.98	1.23	0.751	0.9			
	BL3	2.01	1.23	0.748	0.907			
	BL4	2.05	1.26	0.660	0.918			
Construct	Items	Mean	Standard deviation	Factor loading	SRW	Alpha	CR	AVE
	BL5	2.16	1.28	0.629	0.92			
	BL6	2.15	1.32	0.568	0.872			
	BL7	2.07	1.25	0.721	0.935			
	BL8	2.06	1.23	0.720	0.924			
E-Word of Mouth (EWM)	EWM1	2.13	1.27	0.736	0.872	0.850	0.950	0.827
	EWM2	2.13	1.28	0.704	0.91			
	EWM3	2.05	1.25	0.712	0.932			
	EWM4	2.09	1.20	0.705	0.923			
Brand loyalty (BL)	BRL1	2.03	1.18	0.653	0.902	0.757	0.975	0.828

Brand Loyalty (BL) is measured using six statements given by Carroll, *et al.*, (2006), Shahid *et al.*, (2020), possessing a 0.757 Cronbach's alpha, a CR of 0.957, and an AVE of 0.789. All metrics are deemed appropriate for this investigation. Table 2 also lists the mean, standard deviation, factor loadings, and standardized regression weight for each statement utilized in this investigation.

Research Results

The respondents were from age group of 18 years to 35 years and the majority of them were from the age group of 22 years to 25 years. The respondents were the owners of Apple, Samsung, Google pixel Gadgets and Accessories. 69 percent of respondents were male and rests were female.

Correlation and Discriminant Validity

Table 2 reflects the value of correlation analysis. All the correlation values of variables are mentioned in the below mentioned table. The values of r (coefficient of correlation) of the variables are also presented in the

table. The results confirm the relationship between BLT and BL (0.251**), BT and BL (0.163**), e-word of mouth and BL (0.149**), e-word of mouth and BLT (0.297**) and e-word of mouth and BT (0.105**).

Table 2: Correlation Analysis

	BL	BRL	BT	EWM
BL	1			
BRL	0.251**	1		
BT	0.163**	0.289**	1	
EWM	0.149**	0.297**	0.105**	1

Table 3: Discriminant Validity

	CR	AVE	MSV	MaxR(H)	BRL	EWM	BT	BL
BRL	0.957	0.789	0.088	0.962	0.888			
EWM	0.950	0.827	0.088	0.953	0.297	0.910		
BT	0.965	0.797	0.069	0.966	0.189	0.105	0.893	
BL	0.975	0.828	0.069	0.976	0.151	0.249	0.263	0.910

The values for discriminant validity are shown in Table 3 with clarity. The inter-construct correlation values and square root of AVE were then calculated to evaluate the constructs' discriminant validity. As shown in the preceding table, discriminant validity was observed because the square root of AVE is greater than the values of the inter-construct correlations for all the variables (Fornell and Larcker, 1981).

Table 4: Model Fit Indices

CMIN/DF	2.458
CFI	0.956
GFI	0.806
TLI	0.951
IFI	0.956
RMSEA	0.077

The CFA approach determines how specific factor in a model represents data using a model fit indices. The model has been validated. For such a structural model, CMIN/DF = 2.458 was found to be an acceptable fit. (As high as 5.0, Kline, (1998), GFI = 0.806 (>0.80, Hooper *et al.*, (2008) CFI=0.956 (>0.90, Hu and Bentler, (1999), TLI = 0.951 (>0.90, Hooper *et al.*, (2008), RMSEA = 0.077 (<0.07, MacCallum, *et al.*, (1996) and between 0.08 to 0.10, Mac Callum *et al.*, (1996), IFI=0.956. As per the study's hypothesized structured model, all paths were statistically relevant considering overall p-values less than 0.05.

Table 5: Regression Analysis

	B	Se	T	Sig	Hypothesis
BT-BRL	0.959	0.027	3.371	.001	Supported (H1)
BRL-EWM	0.987	0.011	95.053	.000	Supported (H2)
BRL-BL	0.966	0.017	58.598	.000	Supported (H3)
EWM-BL	0.968	0.016	59.596	.000	Supported (H4)

It is evident from the result of the study that brand trust (BT) has a significant effect on BL (BL), with values b (0.959), t (3.371), and p<0.05 all seem to be positive. Therefore, hypothesis 1 is supported in this study. It is also indicated in the study that BL is significantly related with electronic word of mouth (EWM), where the values of the result are b (0.987), t (95.053), and p<0.05 all seem to be positive. Therefore, hypothesis 2 is supported in this study. It is also noted that brand love (BL) has a significant effect on BLT (BL), the values of the analysis reflects that b (0.966), t (58.598), and p<0.05 all seem to be positive. Therefore, hypothesis 3 is supported in this study. The result of the study also indicated that electronic word of mouth has positive effect

(EWM) of BLT (BL), the result of the study indicates the same which are b (0.968), t (59.596), and $p < 0.05$ all seem to be positive. Therefore, hypothesis 4 is supported in this study.

Table 6: Results Of Mediation Through Process Macro-Analysis

				95% confidence interval		Mediation
				LLCI	ULCI	
Bootstrapping	Direct effect	Indirect	BootSE			
BRL → EWM → BL	0.1765	0.7771	0.0730	0.5988	0.8843	Full Mediation

Note: i) $N = 250$

ii) LLCI = lower-level confidence interval; ULCI = upper-level confidence interval,

iii) *significant at the 0.05 level; ** significance at the 0.01 level; *** $P \neq 0.005$.

As per the mediation analysis, it has been found that electronic word of mouth has meditating effect on brand love (BL) and brand loyalty (BLT). Furthermore, the interval values for indirect effect between the lower confidence interval CI and the upper confidence level CI were not zero (as shown in Table), indicating that there was an indirect effect (Zhao *et al.*, 2010). The statistics shown that the indirect effect is slightly more as compared to the direct effect, as shown in Table. As a result, the study discovered a considerable indirect effect and a direct effect. Therefore, it has been concluded that there was full mediation effect (Jacoby and Jaccard, 2010) in the study. As a result, hypothesis 5 was supported.

Discussion

The study broadened the perspective and understanding of academicians towards forming association of BL, BT and BLT leading to positive eWOM of luxury brands gadgets and accessories.

This study reveals positive association of BT with the BL and subsequently BL with BLT through electronic word of mouth among consumers of luxury brands gadgets and accessories. The results of the study shows that BT has a significant positive effect on brand love (BL), with values b (0.959), t (3.371), and $p < 0.05$. This finding commemorates with the findings of (Zhang *et al.*, 2020).

The study has empirically proven that BL is significantly related with electronic word of mouth (EWM), where the values of the result are b (0.987), t (95.053), and $p < 0.05$. This finding is in line with the previous findings of (Liao *et al.*, 2011; Wu, 2017; Albert and Merunka, 2013).

Brand love (BL) has a significant effect on brand loyalty (BLT), the values of the analysis reflects that b (0.966), t (58.598), and $p < 0.05$ all seem to be positive. This finding is in line with study done by (Nawaz *et al.*, 2020).

As per the mediation analysis, it has been found that electronic word of mouth has meditating effect on BL and BLT. Electronic word of mouth has positive effect (EWM) of BLT, the result of the study indicates the same which are b (0.968), t (59.596), and $p < 0.05$ all seem to be positive (Mazzarol *et al.*, 2007; Srinivasan *et al.*, 2002) results are in parallel to the results of our study.

Overall, the findings of this study accentuated roles of luxury brand customers who are brand loyal, trust the brand and their BL forms positive word of mouth for future customers.

Managerial Implication: The results of this study have immense insinuations and indications for marketers and brand managers of luxury brands. Predominantly, the constructs were measured in the context of Apple, Samsung, Google products in India. The result of the study has indicated that Brand trust is important for Brand loyalty. The practitioners of marketing specialist need to understand the significance of trust among consumers. Trust play very crucial role not only in case of luxury brands but also other products and services. Companies try to build trust among customers through strategic layout. It takes much more time to build trust and convince that the offering is of quality. Therefore, it is suggested to the marketing professionals that never compromise with the trust of the consumers, as it leads to the BL. The result of the study also indicates that BL is likewise essential for the consumers and leads their behaviour to BLT. A loyal customer helps in mounting positive brand image.

Further, the study also found that electronic word of mouth has full mediating effect between BL and BLT. This clearly shows that customers in love with luxury gadgets and accessories are mentioning positive about it. The

electronic word of mouth helps to build brands strong image and gain brands in their sales and popularity. Therefore, it is suggested to the brand managers that they should promote the electronic word of mouth through their satisfied customers loving their products.

Theoretical Implication: This study is also having a great implication for researchers and academicians. The findings of the study suggest that BT is related with BL and love leads to the loyalty among consumers. It was also indicative that consumer's positive views on electronic platform play the crucial role in developing positive view about the products and services. This study is validating the brand resonance model through its findings. Researchers can think of developing some other model which signifies the role of electronic word of mouth for brand advocacy and value creation. It is the power of consumer voice which develops positive and negative opinion regarding the products and services. Researchers need to find some other important variable for developing BLT among consumers. This study signifies that luxury gadgets users are greatly influenced by the electronic word of mouth. If such a premium category product users get influenced by it. Similarly, it can influence the behavior of other product and service users as well. Similar research model can be used to study the other products and services as well.

Conclusion

This study is related with Understanding Brand Love in Luxury brands Gadgets and Accessories. We also tried to find out the mediating effect of electronic word of mouth between the relationship of BL and BLT. Though similar studies have been done to establish the relationship between BT, BL and BLT. While this study is specifically focused on Apple, Samsung, Google Pixel users. The result of the study indicates that BT is significantly related with BL. Here it is also indicative that BL is positively related with BLT. Furthermore, this study also signifies the mediating effect of word of mouth between the relationship of BL and BLT. The novelty in this study is that college going students are greatly influenced by the electronic word of mouth. This can be game changer for many of the products in the country if they are targeting similar type of product users. In conclusion it can be said that consumers in the country using Luxury Brand Gadgets and Accessories develops BL through BT. The result of the study reflects the same.

Brand Loyalty of Luxury Brand users is important for developing BLT. In today's time digital marketing is playing very crucial role in advertising and influencing the behavior and choices of the consumers. Therefore, the current study has investigated the role of electronic word of mouth as a mediator. The result of the study has found that it fully mediates the relationship between BL and BLT. This study also validates the brand resonance model (Keller, 2013).

Limitations and Scope for Future Studies

This study has made an important contribution to the research literature. However, there are also few limitations to the present study. Some other major factors also can play a significant role in mediating the relationship between BL and BLT. Few other variables can also be studied such as brand identity, brand equity, social media marketing, brand evangelism, online brand engagement and brand relationship in future studies. Same research model can be moderated by the control variables to see the effect of gender on the same. Future studies can be conducted using both qualitative and quantitative techniques. Finally, identical research can be conducted using more sample size to see the relationship of these variables.

Forthcoming research can be conducted with the same framework as benchmark. Further study can be done employing larger sample size from respondents belonging to other geographical regions. The present research has used only Luxury brands in mobile/pc gadgets and accessories, which can be extended to brands from FMCG's, automobile or fashion industry. The current study has used electronic word of mouth as moderating variable which can be restructured and /or demographics can also be used to moderate the research model.

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Competency Dynamics of Appraisers in Engineering Units: Empirical Insights from Kolhapur District

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Abstract

This study investigates the key factors influencing the competency of performance appraisers within engineering industrial units in Kolhapur district, Maharashtra. Using a mixed-methods approach, the research combines quantitative surveys and qualitative interviews to capture the perspectives of 120 appraisers and management staff. The analysis focuses on five critical dimensions: educational background, professional experience, training and development programs, technological proficiency, and organizational culture, to determine their impact on the effectiveness and accuracy of performance appraisals. The findings reveal that professional industrial experience and participation in structured training and development programs significantly enhance appraisers' competency and effectiveness. Appraisers with extensive industrial exposure exhibit better understanding and judgment in performance evaluations. Training programs focusing on skill-building and appraisal techniques were found to directly impact appraisal accuracy. Furthermore, the study highlights the contribution of higher educational qualifications and technological proficiency, with appraisers possessing advanced education and familiarity with digital appraisal tools delivering more precise and unbiased evaluations. Organizational culture also emerges as a critical determinant, shaping the attitudes and behaviors of appraisers. Supportive environments that foster collaboration and learning were shown to enhance competency, while rigid or hierarchical cultures posed barriers to effective appraisal practices. Correlation and regression analyses substantiate these findings, demonstrating strong relationships between training, technological integration, and organizational culture with improved appraiser performance. The study underscores the need for targeted interventions to address competency gaps. It provides actionable recommendations for practitioners, such as implementing regular training programs, introducing technology-driven appraisal systems, and fostering inclusive organizational cultures. These initiatives are vital for ensuring accurate performance evaluations, which in turn drive better decision-making and organizational outcomes. For scholars, this research contributes to the literature on performance appraisal systems by offering empirical insights into the dynamics of appraiser competency in the engineering sector. This comprehensive analysis bridges the gap between theoretical frameworks and practical implementation, emphasizing that sustained investment in education, technology, and culture is essential for optimizing appraisal processes. By enhancing the skillsets and tools available to appraisers, engineering industrial units can achieve more equitable and efficient performance management systems, ultimately contributing to overall productivity and organizational growth.

Keywords: Appraiser's competency, Employee performance, Performance Management, Organizational outcomes, Engineering industry.

Introduction

Appraisal competencies make a significant input as far as performance evaluation is concerned in industries, especially engineering ones. This paper established a relationship between appraisal practices both in the general scope of employee development, productivity, and organizational efficiency in engineering industrial units and the quality of appraisals in Kolhapur district, Maharashtra. Although given its importance, this area lacks well-defined literature about factors that influence appraiser competency in this scenario. To this end, this study addresses the following research questions: What are the determinants of appraiser performance concerning education qualification, experience, training, technological awareness, and organizational culture? Since this study sought both qualitative interviews and basic quantitative survey data, 120 appraisers and management personnel were interviewed. The study aims to explore the details of the relationship between these factors and the accuracy and efficacy of appraisal. Concerning these dynamics, the study aims to provide some recommendations, which may help to increase the level of competency of appraisers, in the framework of the developed overall recommendations to improve the quality of the industry. These findings are significant to future HR practices, and performance management methods applicable to the engineering industry.

Problem Statement

In the engineering area, specifically in the Kolhapur district of Maharashtra, performance appraisal is essential to increase employees' productivity, development, and overall organizational performance management. Nevertheless, there remains very little empirical work on the factors that make appraisers competent in this particular context. Although the importance of appraisers' competencies for correct and fair performance evaluations is known, the determinants including educational qualification, professional experience, training program, computer literateness, and organizational culture are also likely to have a great impact on appraisal quality. These factors however have not been sufficiently explored in the existing literature, particularly within the engineering industry in Kolhapur. This study attempts to fill this gap by investigating the role of these variables in the competency of the appraisers based on the relationship between technical awareness, training and development opportunities, and organizational environment with the utilization of performance appraisals. Thus, the problem becomes one of identifying and analyzing those critical factors that influence the competency of appraisers, and their impact on the accuracy and fairness of the performance appraisals, thereby proposing such actionable recommendations for practicing appraisals. In the engineering sector, improving appraiser competency is necessary to improve employee performance, deepen professional growth, and optimize organizational outcomes.

This study investigates the impact of technical awareness, training opportunities, and organizational environment on appraiser competency, focusing on their effects on the accuracy and fairness of performance appraisals. Enhancing appraiser skills is essential for fair evaluations, employee development, and organizational success.

Research Questions:

1. What factors influence appraiser competency in Kolhapur's engineering sector?
2. How do training, technical awareness, and organizational culture affect appraisal accuracy and fairness?
3. What strategies can improve appraiser competency and appraisal effectiveness?

Research Objectives

1. To identify the key factors influencing appraiser competency in the engineering sector of Kolhapur
2. To analyze the impact of training, technical awareness, and organizational culture on the accuracy and fairness of performance appraisals conducted by appraisers

Hypothesis

Hypothesis 1: The competency level of appraisers depends on their educational background.

Hypothesis 2: Appraiser competency and professional industrial experience are positively correlated

Hypothesis 3: There is a relationship between the competency of appraisers and their involvement in the training & development program.

Significance Of The Study

For several reasons, this study is important. Secondly, it addresses a notable gap in the literature by empirically analyzing factors about appraiser competency in the engineering sector, in Kolhapur, Maharashtra especially where little such research has been conducted. The study examines how such variables, for example, education, professional experience, training programs, technological proficiency, and organizational culture, relate to appraiser effectiveness and how this may influence performance appraisal quality. We further examine the implications of these findings for practical applications in Human Resource Management through actionable recommendations for enhancing appraiser competencies and finally facilitating high-quality and fair performance evaluation. This then increases employee development, productivity, and organizational performance. The study also contributes to the broader aim to create a culture of continuous improvement across the wider engineering sector given its importance for the industry's competitive making. Lastly, the research provides information on HR practices and policy decisions to develop better performance management strategies and adopt the appropriate interventions needed for the optimization of employee and organizational outcomes

Literature Review

Aguinis, H. (2009). Performance management (2nd ed.). In this book the author provides a comprehensive literature review focusing on performance management systems and using appraiser competency as a measure to increase the accuracy of employee ratings. The importance of appraiser competency in ensuring accurate employee evaluations. Aguinis also considers many sources of evidence that own the impact of appraisals, with an account of the level of appraiser training, the forms of feedback, and the corporate culture.

Pulakos, E. D. (2004). Performance management: The new way of achieving a successful outcome. • Pulakos discusses how the competency of the appraiser influences the effectiveness of the performance management system. review of performance management systems, emphasizing the importance of appraiser competency in ensuring accurate employee evaluations. Aguinis discusses various factors that influence the effectiveness of appraisals, including appraiser training, feedback mechanisms, and organizational culture.

Sharma, S. and Singh, A., 2015 Sharma and Singh (2015) examine the effects of organizational culture within performance assessments of appraiser competency. That is, they discover that a positive culture of trust, clarity, and support leads to the reliability and validity of the appraiser. This study therefore notes that organizations in the private sector, which embrace performance management and organizational culture motivating performance, generally have better appraisal systems than those in the public sector, which adopts more bureaucratic organizational cultures. Altogether, the open and learning communication organizational culture enhances appraiser competency in the assessment of the employees' performances.

DeNisi, A. S., & Pritchard, R. D. (2006). Based on this study, we have a framework with which to understand how appraiser competencies (such as experience and training) relate to individual performance outcomes as well as the quality of performance appraisals. Motivation theories for performance evaluation and appraiser skills are discussed by the authors.

Brown, M., & Heywood, J. S. (2005) This study looks at appraiser competency in managerial decision-making, with a focus on how hours of experience and educational background influence more accurate and accurate appraisals in industrial settings.

Kuvaas, B. (2006). In this paper, Kuvaas investigates the relationship between employee motivation and appraiser competency and notes that flawed performance appraisals originate in appraisers who are not sufficiently competent to provide constructive feedback and set clear performance goals.

Borman, W. C., & Motowidlo, S. J. (1997). This paper highlights the different competencies that appraisers need to apply while rating both tasks and contextual performance. It offers the appraisers a sound conceptual model through which they can assess both types of performance efficiently.

Kellough, J. E., & Nigro, L. G. (2002) Though carried out in the public sector, this research is very useful in performance appraisal with special stress on the features like training, experience, and qualification of the appraiser.

Rothwell, W. J., & Kazanas, H. C. (2003). Rothwell and Kazanas also examine the implication of training and development programs that are ongoing in perspective to competency improvement of appraisers especially in technical areas like engineering that have new tools, methods, and methodologies..

Meyer, J. P., & Allen, N. J. (1997). The present volume looks into experiences that underpin the competency of appraisers on how organizational culture affects the same.. How commitment culture enhances accident analysis, appraisal, and evaluation by examiners is the topic.

Landy, F. J., & Farr, J. L. (1980) This paper aims to review the performance rating systems and appraiser competency in providing accurate and valid performance. appraisals.. This led to the conclusion that training, experience, and beliefs as well as attitudes of the appraisers directly affected the degree of accuracy shown in appraisal.

Venkatesh and Kumar (2016) in their study "Technological Integration in Performance Management: In "A Study on Indian Appraisers' Competency", the use of technology has been discussed in the expression the competency of appraisers in India. The study is centered on how the use of technology tools including performance management software, data analytics, and other digital platforms influences the capability of appraisers to evaluate the level of productivity of the employees. The authors state that technology it enables the appraiser to make better decisions, is more accurate, and less prejudiced in assessment. Additionally, the research finds out that since appraisers with high technological literacy can easily work with complicated performance information can monitor the progress of employees, and give timely feedback, they suit the job better. However, the study also proves that technology implementation is on the age of how appraisers are trained and supported and whether the skeptical community accepts it. All in all, the findings of the study hold strong evidence that advancing appraiser-embedded technologies premised on performance management increases overall competencies through improving procedural efficiency and decision-based accuracy.

Research Methodology

The research methodology adopted to study factors influencing the competency of appraisers in engineering industrial units in Kolhapur district, Maharashtra has been described in this section. The methodology of this study involves research design, population, and sampling, data collection methods as well as data analysis techniques.

Research Design

For this study, a mixed method approach was used—comprised of both qualitative and quantitative research methods. The approach was to provide for a thorough examination of appraiser competency through the combination of numerical data analysis with a deep dive into interview data. Quantitative was devoted to determining the relationships among certain factors (such as educational qualifications, years of work experience, training experience, etc.) and appliance competency. The qualitative component interviewed appraisers and management personnel and helped it to understand these factors better.

Population and Sampling

Population:

For this study appraisers and management personnel were taken from engineering industrial units in Kolhapur district of Maharashtra. They are the ones in charge of evaluating employees' performance in the cases of manufacturing and technical jobs. Appraisers with technical as well as managerial backgrounds actively participating in performance appraisals are the target population.

Sampling Method:

A stratified random sampling technique was employed to include a diverse range of appraisers and managerial personnel. Strata were formed based on an organizational level (line manager, department head, and senior) and individuals were randomly selected from each stratum. Such a sample size is enough to perform statistical analysis in quantitative research; therefore it was 120 respondents.

Inclusion Criteria:

- Respondents must be actively involved within the industrial unit in the performance appraisal process.
- Appraisers should have a minimum of 1 year of experience within the industrial unit.

Data Collection Methods

The study adopted two primary data collection methods: structured surveys and semi-structured interviews.

a) Structured Surveys:

A structured questionnaire was developed to collect quantitative data. The questionnaire consisted of **closed-ended questions** designed to assess the following variables: Quantitative data were collected by developing a structured questionnaire. It involves closed-ended questions by including the following variables.

- **Educational Backgrounds** (e.g., Higher educational qualification, specialized degrees)
- **Professional Industrial Experience** (e.g., Total number of years of experience, relevant experience)
- **Training and Development Programs** (e.g., frequency and type of training (and participation in training workshops)
- **Technological Proficiency** (e.g., familiarity with using appraisal software, familiarity with data analytics tools)
- **Organizational Culture** (e.g., feedback culture, support for learning)
- **Appraiser Competency** (e.g. accuracy and consistency in evaluations, the capacity to specify reasonable performance standards, the capacity to provide constructive feedback, and the overall usefulness of the appraisal process in developing employee performance.)

Items to measure the perceived influence of these factors on respondents' competency as appraisers were rated from 1 (Strongly Disagree) to 5 (Strongly Agree).

Semi-Structured Interviews:

In-depth semi-structured interviews with 120 appraiser managers and senior appraisers were held to provide insight into the determinants of appraiser competency. The following were to be explored in the interview guide

- Experiences with training and development programs.

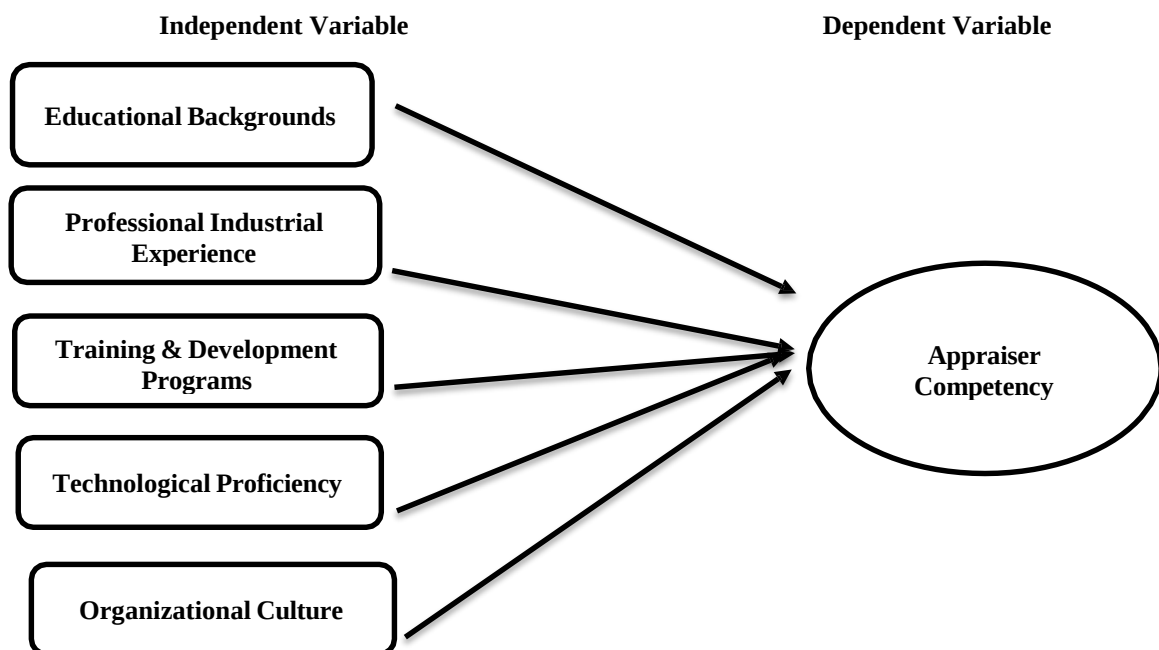
- Organization Culture Perceptions and their Effect on Accuracy of Appraisal.
- Issues of using technological tools for challenging appraisal
- Recommendations to enhance appraiser competency.

These interviews were **audio-recorded** and transcribed for analysis.

Conceptual Framework

The overall success of employee performance appraisal depends on the efficiency of performers who appraise or give feedback on the subject. Bias and prejudice enter into such decisions depending on certain factors that may affect the competency of an appraiser to make sound decisions and come up with a fair evaluation. This study identified the ability to define and understand the several components of appraiser competency to be crucial in enhancing performance appraisal systems. Decisions made by the personnel relate to the appraiser's education, work experience, training, development, technology competence, and organizational culture. The following conceptual framework demonstrated how these factors interplay and affect the competency of the appraisers while assessing the employees' performance.

Graph 1: Conceptual framework of Key Variables of Factors impacting on Appraiser's competence



*Source - Author's Independent Assessment.

As the following is the framework that reveals the factors influencing an appraiser's competence while appraising the employee's performances, shows the following factors include the following; educated background, the experience of the appraiser, training and development, technological skills, and organizational culture. There are good reasons for this: a strong academic background gives appraisers the appropriate knowledge, while professional experience refines these individuals' ability to implement this knowledge in practical evaluations. Continuing education makes appraisers up-to-date with current practices in the market and technological skills make their evaluations effective and quicker. Furthermore, the organizational environment drives the learning process, teamwork, and knowledge, all of which develop a competent appraiser in the field of employee assessment.

Results

The findings of data analysis based on determining the competency of appraisers in engineering industrial units in Kolhapur district Maharashtra are presented in this chapter. As discussed in the research methodology chapter, descriptive statistics were used to perform the data analysis and hypothesis testing. This analysis zeros in on some of the major factors —degrees, experience, training programs, technology familiarities, and culture. Work context dimensions were conjectured to have salient implications on appraiser competence.

Demographic Statistics

Table No. 1 Demographic Statistics of Appraiser's

Demographic Category	Details	Count (%)
Total Respondents	No. of Appraisers	120
Gender Distribution	Male	102 (85%)
	Female	18 (15%)
Age Distribution	18-30 years	30 (25%)
	31-40 years	42 (35%)
	41-50 years	30 (25%)
	51+ years	18 (15%)
Educational Background	Diploma Holders	36 (30%)
	Bachelor's Degree	66 (55%)
	Master's Degree	18 (15%)
Professional Industrial Experience	0-5 years	24 (20%)
	6-10 years	48 (40%)
	10+ years	48 (40%)

*Source - Author's independent assessment.

Descriptive Statistics

We computed descriptive statistics to summarize the data and better understand the general distribution of responses for each key variable (i.e., education credentials, work experience, training programs/technology exposure, and organizational culture) and appraiser competency. These statistics help summarize the data before going deeper by analyzing and testing a hypothesis.

Table 2: Descriptive Statistics Of Key Variables Of Factors Impacting On Appraiser's Competence

Variable	Mean	Standard Deviation	Min	Max
Educational Backgrounds	3.82	0.76	2	5
Professional Industrial Experience	4.1	0.81	2	5
Training & Development Programs	3.94	0.85	1	5
Technological Proficiency	4.05	0.78	2	5
Organizational Culture	4.18	0.72	2	5
Appraiser Competency	4.08	0.8	2	5

*Source - Author's independent assessment.

The above table no.1 represents Descriptive Statistics of Key Variables of Factors impacting on Appraiser's competence, analysis is given below

- **Educational Backgrounds:-** According to the results, the percentage of educational backgrounds of appraisers differs significantly from the Average value: 3.82. A coefficient of variation of 0.76 indicates a reasonably high dispersion of participants' educational backgrounds. It also indicates that while some 58 appraisers have little as formal education as a high school diploma, others have as much as a college education with the results ranging from 2 to 5. Appraiser competency is probably positively associated with higher education but there is heterogeneity in the sample.
- **Professional Industrial Experience** The mean score was 4.1, which shows that most of the participants possess substantial professional industrial experience as appraisers. The coefficient of variation of 0.81 shows that data variability is moderate meaning that while a majority of the appraisers may have accumulated more professional experience than the mean, there are some with less experience. The range (2 to 5) indicates that professional experience is highly valued and this we believe will help to enhance the competency of the appraisers.
- **Training & Development Programs:-** The score mean of 3.94 coaxes to the conclusion that while appraisers do attend some training & development programs, they do not do this to the maximum. The moderate value illustrates the fact that variability concerning the level of training is also high, with a

standard deviation of 0.85. The values of the training variable range from 1, which represents a very low level of training among some appraisers to 5, which represents a very high level of training among most appraisers. The nature of the training will enhance the competency of the appraisers, although there is evidence of variation in the participation or access to the training.

- **Technological Proficiency** Appraisers' average score of 4.05 suggests that appraisers are knowledgeable about technology but that there is variation in their technological sophistication. It means that technological familiarity varies moderately with a standard deviation of 0.78; minimum being 2 and maximum being 5. As highlighted in the research questions, the level of experience with technology is probably one of the factors that enhance appraiser competency given the current technological trends in the appraisal process.
- **Organizational Culture:-** This is a favorable mean score of 4.18 which indicates that the organizational culture within which appraisers undertake their work is favorable or rather productive. With a mean of 7.38, the conclusion can be drawn that most of the appraisers are experiencing a positive organizational culture and there may be several appraisers with as low as 2 suggesting that they may not view the organizational culture positively. Work environment support and the aspect of organisation culture which includes appraiser competency can also influence appraiser competency.
- **Appraiser Competency:-** The mean score of the dependent variable, the appraiser competency factor, is 4.08 showing that appraisers generally perceive themselves as competent in their role. The above work proves that there is variation, some appraisers rated themselves lower competency level (2) while others rated higher (5) in terms of competency as shown in SD 0.8. This is evidenced by a variation in the way appraisers reason and perceive their own competency or capability.

The above findings suggest that competency among the appraisers was conditioned by several variables, all of which presented significant variability across the sample. Education and professional background imply a range, more education seems to lead to higher competency estimates, yet a lot of variability is observed. The majority of appraisers have many years of prior professional experience; however, there is variation in experience levels, somewhat low. For the variable training and development programs, although appraisers engaged in the programs, the level of their engagement seems to indicate more growth that may be achieved in the future. Skill in technological application appears generally high though, not consistently with significant differences between appraisers in the current studies revealing tendencies toward still higher technological competence. Employees perceive the organizational culture more or less in a positive light, but a few might have had negative experiences from which their competency could be affected. In summary, although appraisers overall feel competent in their evaluation skills, the variability of response to this self-evaluation question underscores the fact that education, experience, training, technology, and culture combine to produce competency.

Correlation Analysis

Table 2: Pearson's Correlation Coefficients for Key Variables and Appraiser Competency

Variable	Educational Backgrounds	Professional Industrial Experience	Training & Development Programs	Technological Proficiency	Organizational Culture	Appraiser Competency
Educational Backgrounds	1	0.56**	0.45**	0.40**	0.53**	0.61**
Professional Industrial Experience	0.56**	1	0.50**	0.45**	0.60**	0.65**
Training & Development Programs	0.45**	0.50**	1	0.56**	0.58**	0.60**
Technological Proficiency	0.40**	0.45**	0.56**	1	0.52**	0.63**
Organizational Culture	0.53**	0.60**	0.58**	0.52**	1	0.70**
Appraiser Competency	0.61**	0.65**	0.60**	0.63**	0.70**	1
Note: p < 0.01						

*Source - Author's independent assessment.

The correlation coefficients from above table no.2 indicate strong positive relationships between all the key factors. These results support the hypothesis that factors such as education, experience, training, technology, and organizational culture all have a positive influence on appraiser competency.

- The appraiser's educational level is positively correlated with appraiser competency at about a moderate level of $r = 0.61$. Most appraisers who have qualifications tend to be competent appraisers.
- The appraiser's professional experience is also highly correlated with the performance level of appraisers at $r = 0.65$ which means, the more professional experience and competence the higher the performance.
- Attending training and interacting with technologies also appeared to have positive relations with the appraiser's ability performance level at $r = 0.60$ and $r = 0.63$ respectively which proves that the two practices are relevant in improving the accuracy of appraisal.
- At $r = 0.70$ organizational culture has the strongest relationship with the appraiser's ability and therefore where there is a friendly environment that encourages to engage in more learning, the appraisers in the organization perform better.

These results prove that education, experience, training, technology, and organizational culture are all interrelated and positively impact the ability of the appraiser.

Multiple Regression Analysis

To test the interaction effects among the independent variables on perceptual appraiser competency, a multiple regression analysis was run.

Table 3: Multiple Regression Analysis Results

Variable	Unstandardized Coefficient (β)	Standardized Coefficient (β)	t-value	p-value
Constant	1.13		4.52	0
Educational Backgrounds	0.29	0.22	3.68	0
Professional Industrial Experience	0.35	0.28	4.21	0
Training & Development Programs	0.23	0.18	2.97	0.003
Technological Proficiency	0.27	0.21	3.48	0.001
Organizational Culture	0.4	0.33	5.11	0
$R^2 = 0.70$ (Adjusted $R^2 = 0.68$)				

*Source - Author's independent assessment.

The results of the multiple regression analysis from above table no. 3 revealed that all the research independent variables are significant and positive predictors of appraiser competency

- Organizational Culture had the highest standardized coefficient of 0.33 while Professional Experience had 0.28 and Educational Qualification had a coefficient of 0.22. Based on this, it can be deduced that the organizational enabler and both experience and education are most likely to define appraiser competency.
- Training Programs and Technological Familiarity are also other determinants of appraiser competency and like the two above, they have a slightly lower coefficient compared to organizational culture and experience.

The value obtained of 0.70 shows that the independent variables used can account for 70% of the variation in competency of appraisers. This is a high percentage, which indicates that the model was an adequate fit with the values obtained in the data.

Hypothesis Testing

The hypotheses were analyzed through t-tests and ANOVA to establish the statistical difference where the degree of competency of the appraisers was measured using subsets such as; educational background, number of professional years of experience, and participation in training activities.

- **Hypothesis 1:** The competency level of appraisers depends on their educational background.
 - **t-test result:** The 't' value was also significant at 3.68 with a 'p' value < 0.01 . Therefore, this hypothesis that individuals with higher levels of educational qualification are likely to be more competent appraisers was boosted.
- **Hypothesis 2:** Appraiser competency and professional industrial experience are positively correlated at a level of significance of 0.05.
 - **t-test result:** The t-test was also significant with $t = 4.21$ at $p < 0.01$; this underscores the fact that more experienced appraisers are more competent.
- **Hypothesis 3:** There is a relationship between the competency of appraisers and their involvement in the training and development program.

- **ANOVA result:** The p-value was also significant ($p = 0.003$), meaning that appraisers who engage in regular training show a higher competency than those who do not engage in training programs.

Discussion & Implication

This chapter discusses the results of the study regarding determinants of appraiser competency in engineering industrial units in the Kolhapur district of Maharashtra. The research explored five vital factors impacting appraiser competency: formal academic and/or part certification achievement, work experience, training, technology literacy, and organizational climate. All five factors posed a positive correlation with competencies among appraisers but organizational culture featured most prominently

Interpretation of Findings

Educational Backgrounds: Educational qualifications are strongly correlated with appraiser competency ($r = 0.61$), suggesting that higher levels of education translate into better performance appraisal by appraisers. While it impacts more than experience or organizational culture, it's not anywhere near as powerful.

Professional Industrial Experience: Professional experience was found to be a major determinant of competency, with a correlation of $r = 0.65$. The more experience an appraiser has, the more likely he or she is to make better decisions and assess performance more effectively.

Training & Development Programs: Appraiser competency was highly correlated with training programs ($r = 0.60$). All of this reinforces the idea that ongoing training will improve appraisal skills and knowledge, keeping appraisers' skills and knowledge current with industry standards and evaluation methods.

Technological Proficiency: Support was found for a positive effect on appraiser competency ($r = 0.63$). Using performance management software and data analytics, appraisers who are proficient with technology can reach more accurate, more informed appraisals.

Organizational Culture: The strongest correlation ($r = 0.70$) between organizational culture and appraiser competency was displayed in this. By creating an environment of trust, accountability, and continuous learning, a supportive and collaborative culture helps to create a better-performing appraiser.

Practical Implications

To strengthen appraiser competency, the organizations need to emphasize on the following:

- Ensure consistent and timely training to upgrade general appraiser skills and knowledge.
- Use innovative technologies to help in appraising the property accurately and faster.
- Foster an organizational climate where there is synergy to learn and share ideas.
- Hire fairly experienced appraisers to deliver the assessments needed and maintain the quality.

Limitations and Future Research

There are some limitations to this research since it is specifically concerned with engineering industrial units in Kolhapur whose generalization may not be relevant in all contexts. In the future, however, the research could be extended to cover other areas and industries or include studies that would demonstrate how appraiser competency changes over time. Furthermore, a more in-depth view of appraiser competency could be achieved by examining the impact of various external factors, for instance, trends in the industry or general economic conditions.

Conclusion

Correct appraisers in an organization are a pre-requisite in the effectiveness and fairness of performance evaluation within any organization especially in the engineering sector where precise and accurate appraisals are extremely vital to operational efficiency. In this study, engineering industrial units in Kolhapur district, Maharashtra were analyzed to determine the factors influencing these units' appraiser competency. The results indicate that educational qualifications, professional experience, training programs, technological familiarity, and organizational culture are all statistically significant when explaining appraiser competency. **Key conclusions from the study are as follows:**

1. While educational qualifications aid appraiser competency, this is done moderately, compared to other development factors like company culture and experience.
2. One of the most powerful predictors of competency was professional experience. Informed and accurate assessment is more apt to be made by experienced appraisers.
3. Maintaining high appraiser competency is dependent upon such training programs because these programs enable the appraisers to keep up with continuous development in appraisal techniques and other industry standards.
4. Accurate performance evaluations are facilitated by the fact that appraisers with technology familiarity can make data-driven precise choices.
5. The biggest impact on appraiser competency was found to be organizational culture.

These findings indicate the complexity of appraiser competency and the necessity for organizational ownership of the development of the skills and capabilities of its appraisers.

Finally, we conclude that appraiser competency is a multivariate phenomenon involving education, experience, training, technology, and organizational culture. Improving these factors will prove to be highly advantageous to engineering industries in the Kolhapur district. Companies can strengthen their organizational performance by investing in the development of appraisers utilizing education, training, technology, and a supportive organizational culture to subsequently improve the quality of their performance evaluations and enhance decision-making, employee development, and organizational performance. These efforts will enable organizations to enhance their appraisal process and also develop a more capable and motivated workforce able to address the issues of an industrial environment marked by change.

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Disappearance of River Sarasvati in India - An Environmental Perspective, Lessons for the Future for Revival Management

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Abstract

Many rivers have disappeared from the ground surface of the planet earth in different periods of the history, some of them are codified and some have no records. Climate change is not a current phenomenon in the geological periods. Many civilizations had been destroyed, eliminated and abandoned at different phases. Climate had compelled the settlements to evacuate the cities, fortified locations and establishments. Largely, such events have happened due to scarcity of the water at the ground level, change of the courses of the river – that was the lifeline of the settlement, disappearance of the river because of the destruction of the source of the river. Himalayan rivers are largely glacier fed rivers or rain fed rivers. Only few depend on the perennial streams. The river Sarasvati was a glacier base river and was also depending on the rainfed. The glacier changed its location with glaciation and the river Sarasvati disappeared and caused many civilizations of ancient India to die. Cosmopolitan cities like Dholavira, Kalibangan, Rakhigarhi and couple of others were abandoned. Sarasvati sources have been dictated through ISRO satellite and researchers. Exploratory research with tri- approach model of geography is used in this river disappearance study with representation of source evidences. Many stepwells were constructed on the river Sarasvati bed to access water source in the medieval period. In this century the attempts have been made to recharge the river bed to reactivate the river flow, because of its holy status. Many researches have been conducted for the restoration of the river. One fact gets established that all Himalayan glacier fed rivers will die in this century due to climate change. Literature from the 3000 BCE have been taken into account for the study till the geological satellite findings in this century. Wide variety of researches were examined and evaluated with triangulation approaches; investigative methods used for the establishment of the findings from many sciences for this research. This is specific research from the environmental management perspective for revival of a disappeared river; the Sarsvati.

Keywords: River Sarasvati, Dead River, Disappeared River, River Revival, Climate Change

Introduction

Around 6000 B.C., the Sarasvati River, one of the most fascinating natural features on the Indian Subcontinent, began to flow spectacularly. Described in the Rig Veda as a powerful Himalayan River, it was known as Sapta-Sarasvati due to its six major tributaries (Bhadra et al., 2009). The river ran between the Indus in the west and the Ganges in the east, flowing through present-day Punjab, Haryana, western Rajasthan, and Gujarat, eventually draining into the Arabian Sea via the Gulf of Kutch. Near the confluence of its tributaries, the river expanded to such a vast extent that it resembled an ocean (Srivastava 2018). The river's abundant natural resources fostered thriving human settlements and supported agricultural livelihoods, as well as cultural and educational hubs. However, climatic shifts and tectonic activity in the Himalayan region caused the Sarasvati to dry up around 3000 B.C (Bharadwaj 1999). By the time the later portions of the Rig Veda were composed, the river's prominence had diminished, and its name was gradually replaced by Spata-Sindhu, referring to the Indus and its six tributaries. In the Yajurveda, the focus shifted to Panchanadya, a collective term for the five rivers in the region, and Panchadha, referring to the division of the river into five distributaries (Chatterjee et al., 2019). The Mahabharata's Aaranyak Parva describes the Sarasvati as a once-mighty river that lost its course near a location called Vinasana, on the desert's boundary. Its remnants were reduced to a chain of lakes surrounded by forests, reflecting the river's faded splendour yet serving as a reminder of its significant past (Chopra et al., 2006).

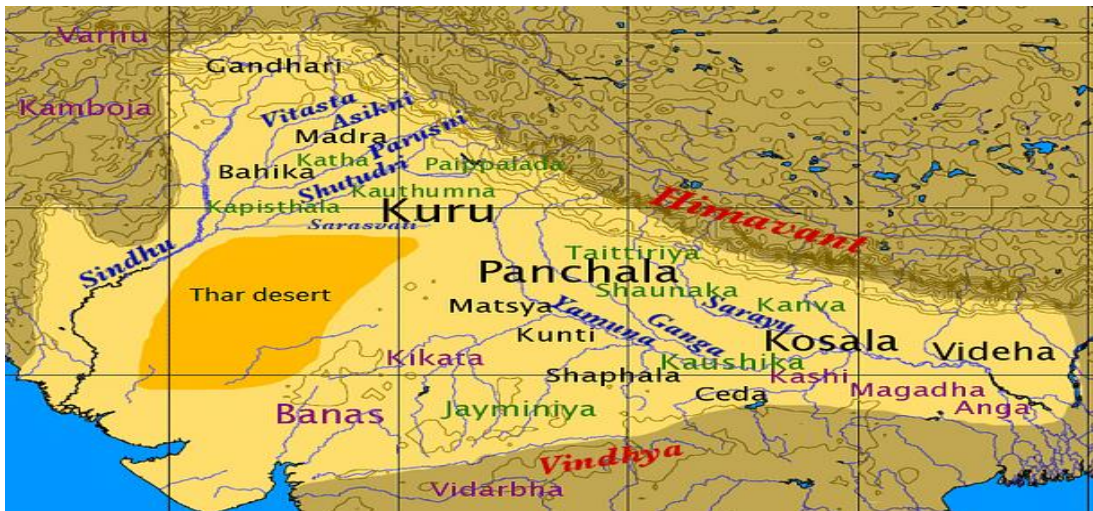


Fig. 1. Rig Vedic Mentioned Mahajanapadas and the Rivers (Sarasvati – the disappeared river)

The existence and eventual desiccation of the Sarasvati River, as referenced in the ancient texts, has long intrigued geologists, geographers, and archaeologists worldwide. This fascination began in 1874 when Oldham of the Geological Survey of India (GSI) published the first report on a 'lost river' in the Indian Desert. Oldham later expanded on these findings in a more detailed account in 1886, published in the Journal of the Asiatic Society of Bengal. Oldham's initial 1874 report discussed traces of a lost river in the Great Indian Desert (Thar Desert) (C.F. Oldham 1874). In a subsequent paper (1893), he proposed that the present-day Ghaggar River, which converges with the Sarasvati near Shatrana, represents the ancient Sarasvati River. According to him, this river, once fed by tributaries such as the Sarasvati and Markanda, flowed westward during the Vedic period but eventually lost its course in the sands of the desert near a place called Vinasana. The dry bed of the Ghaggar River is believed to mark the ancient Sarasvati's course (Hodell, et al., 2019).

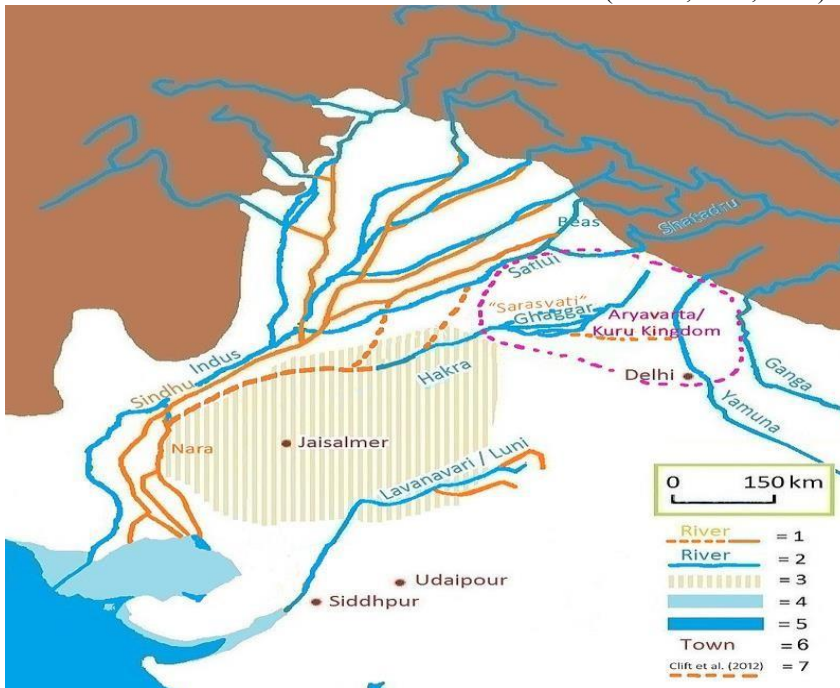


Fig. 2. River Hakra – Bed – (Sarasvati River Channel)

The Indian subcontinent was the scene of dramatic upheavals a few thousand years ago. The northern east region entered an arid phase, and erosion coupled with tectonic events played a great Havoc with river courses. One of them disappeared is the river Sarasvati. Recently the geographical and climatological studies have probed its evaluation and disappearance, while satellite imagery has traced the rivers buried courses and dried beds and isotope analysis have dated ancient water still stored under the Thar Desert of Rajasthan and the Rann of Kutch of Gujarat. Many of the pre Harappan and Harappan civilization sites perished without the water of the

river Sarasvati. Since Aurel Stein's expedition in the 1940's, hundreds of Harappan sites have been identified in the now dry Sarasvati basin.

Research Methodology Used

Such research is highly dependent on geographical methods of managing evidence with triangulatory approaches, linking the physical facts, secondary evidence and scientific surveys and excavations. In a larger context this research has used geographic exploration methods with substantial physical evidence and link based historical evidence of archaeological excavations at different phases in the last two centuries. Some evidence was satellite surveys by the ISRO. Physical evidence spanning over 500 years is used in this research paper.

Origin of the River Sarasvati from Himalaya Mountain Range

Dependencies: Civilization (Dholavira, Lothal Rakhigarhi)

Ancient India's knowledge text "Rigveda" defined the rivers Sarasvati as a lifeline of many human settlements, so this was called the holi river (Kinsley, 1998). The river is also described and explained as a powerful river with mighty flood (Wilke, 2011). In the late 19th century ADE numerous scholars of archaeology and history proposed and explored to identify the Sarasvati with the Ghaggar- Hakra river system, which flows through North- Western India and Eastern Pakistan, between the Yamuna and Sutlej, and ends in the Thar Desert region of Rajasthan and possibly in the Gujarat province in India. (Cleft, et al., 2012). ISRO satellite has observed that major Indus valley Civilization sites at Kalibangan (Rajasthan), Banawali and Rakhigarhi (Haryana), Dholavira and Lothal (Gujarat) lay along the course (Sankaran, 1999). The river dried up some 4000 years ago that is, 2000 BCE becoming an intermittent river, and the urban Harappan Civilization declined along with Dholavira, Lotha, Kalibangan, Rakhigarhi, Banawali in India (Singh, 2017).

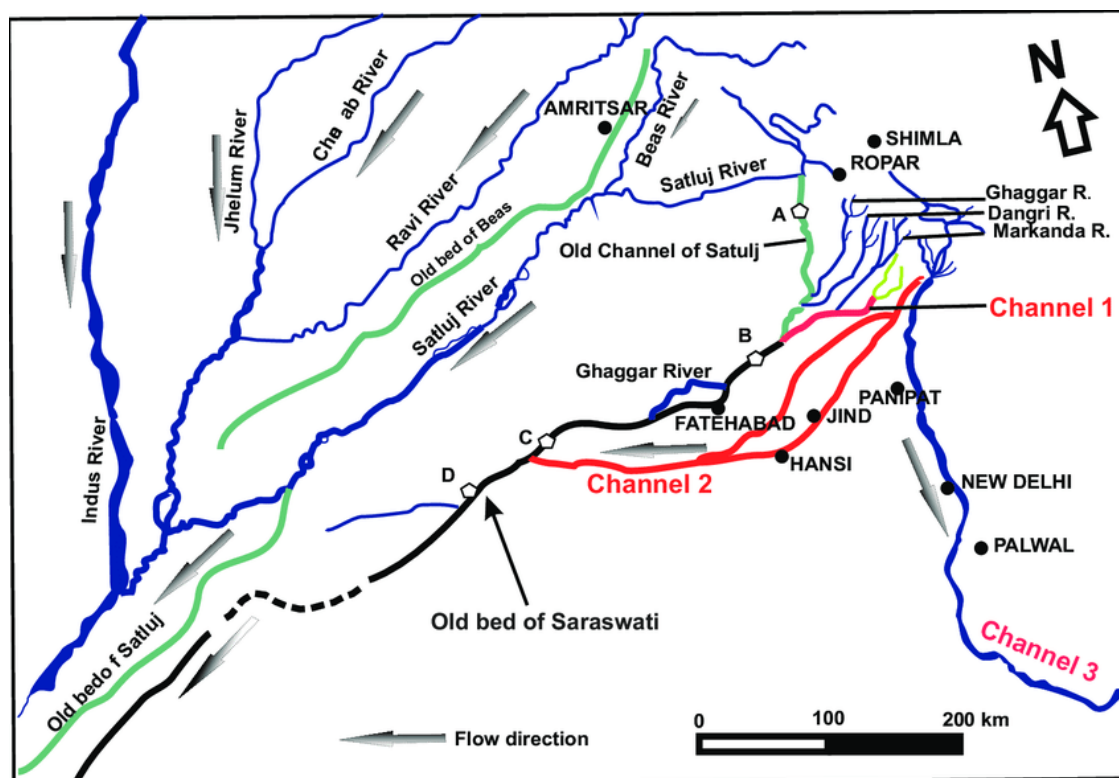


Fig. 3. Old Bed of River Sarasvati (Disappeared River)

The Sarasvati River decline system well establishes the river as a glacier fed drainage system, that drainage system dried due to the displacement or shifting of the glacier on the Himalaya Mountain ranges. Many rivers of India are of Himalayan origin from glaciers and some are rain fed with the impact of the climate change many rivers are subject to dry in the coming century. The first reference to the disappearance of the lower course of the Sarasvati is from the Brahmanas, a treatise, text that are composed in Vedic Sanskrit, but dating to a later date than the Veda Samhita's (Witzel, 2001). Post Vedic texts note that the historical river Sarasvati was a topographically tangible mythogeme, which was already reduced to a small, sorry trickle in the desert, by the time of composition of the Hindu epics (Ibid, 2011). The Ghaggar-Hakra river is a seasonal river in India and Pakistan that flows only in the monsoon season, but satellite images of the Indian Space Research Organisation

have confirmed that the major course of a river ran through the present day Ghaggar River (Valadiya, 2002). In the 2000 BCE, the monsoon diminished and the Ghaggar Hakra fluvial system dried up, affecting the Harappan Civilization. There is a general agreement among the researchers that the river courses in the Indus basin have frequently changed course; the sequences of these changes and their dating have been problematic (Schuldebreil et al. 2004). Many recent publications have shown that the Sutlej and Yamuna shifted course before Harappan times. According to a group of researchers, the Sarasvati River used to flow from the glaciated peaks of the Himalayas to the Arabian sea and an huge amount of water was flowing through this drainage network (Chaudhicietal. 2021) many Indus Valley Civilization sites and urban settlements are found on the banks of and in the proximity of the Ghaggar -Hakra fluvial system. Monsoon fed Ghaggar - Hakra in Harappan times (Stein, 1942). Number of archaeologists and geomorphologists have identified the Sarasvati River with the present day Ghaggar - Hakra Rivers, on the dried up part of it. Before Vedic times the river Sarasvati had already dried- up and became a small seasonal river. In the recent centuries a number of Scholars have identified the Sarasvati River with Ghaggar. Hakra river scholars like Christian Lassen (1800 to 1876), Max Muller (1823 to 1900), Marc Aurel Stein (1862 to 1943), C. F. Oldham and Jane Machintosh have identified the Sarasvati as the Ghaggar Hakra River. Michel Danion notes that the 1500 km long Sarasvati River fed was rediscovered in the 19th century. Most Indologists were convinced in the 19th Century that the river bed of the Ghaggar Hakra was the relic of the Sarasvati (Danino, 2010). Indologist Michel Danino places the composition of the Vedas therefore in the third Millennium BCE, a Millennium earlier than the conventional dates (Danino, 2010). Michel Danino notes that accepting the Rigveda accounts as a mighty river as a factual description, and dating the drying up late in the third Millennium are incompatible. Indus valley Civilization is sometimes called the Sarasvati culture, Sarasvati civilization, Indus Ghaggar-Hakra civilization, Indus Sarasvati civilization. The research and satellite imagery of the state Haryana of India has confirmed to have found the lost Sarasvati River when water was detected during the digging of the dry river bed at Yamunanagar (Nair & Daniel, 2015). Satellite photograph, surveys and researchers have confirmed that there was once a great River that rose in the Himalayas glaciers, entered the plains of Haryana, flowed through the Thar Desert of Rajasthan and Eastern Sindh running roughly parallel to the Indus River and then reached the sea in the Rann of Kutch in Gujarat state. The Marshy landscape of the Rann of Kutch is plentily due to the fact that it was once the estuary of the great river (Bhadra et al 2009). The government constituted Sarasvati Heritage Development Board (SHDB) had conducted a trial run to revive the river bed in Haryana.

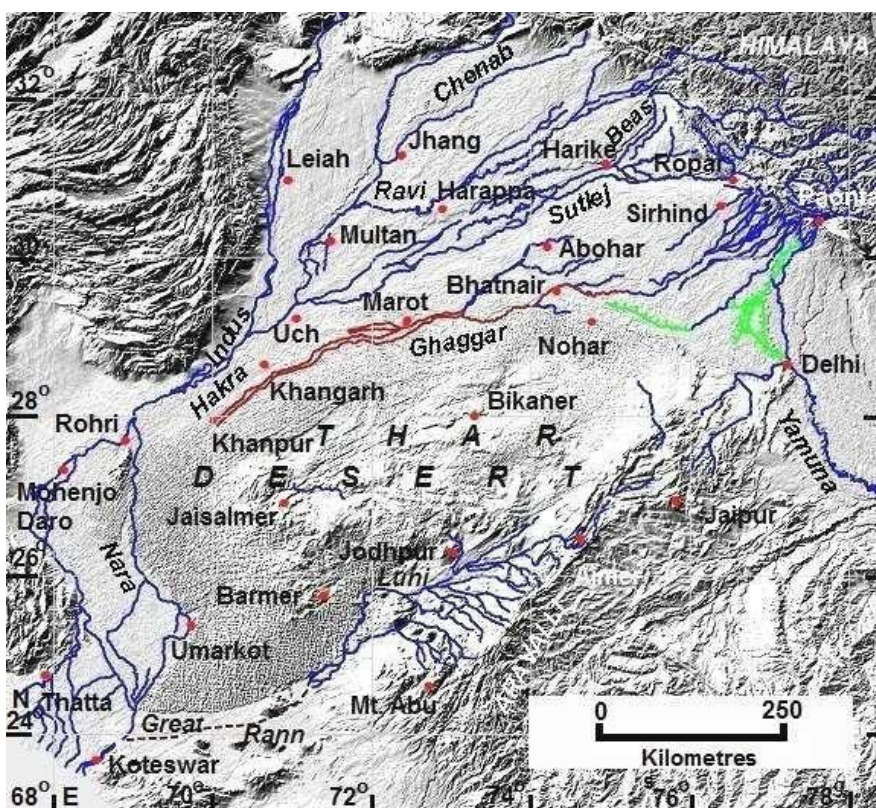


Fig. 4. The Ghaggar-Hakra valley (brownish red), the Nara and few other streams (blue), and some canals (green) from A.K. Johnston's 1873 map of North India which was geo-referenced for the purpose. Background image is a SRTM-1km DEM of the area.

Dholavira - Ancient Cosmopolitan City

In the Kutch district of Gujarat, the archaeological site of an ancient urban cosmopolitan city, Dholavira is located in Bhachau Taluk, at Khadirbet village also known locally as Kotada Timba. The ruins of a city of the Ancient Indus valley Civilization or Sarasvati River bed civilization dates back to 2600 BCE, located on the Tropic of Cancer. It is one of the five longest Harappan sites. Dholavira ruin site is located on Khadir Bet Island in the great Rann of Kutch in Gujarat. The site is spread over 120 acres as a quadrangular city lay between the seasonal streams Mansar in the north and Manhar in the south. This Ancient city was occupied from 3500 BCE till 1800 BCE. The ruins of the city were discovered in the 1960s by Archaeological Survey of India. The major Harappan sites discovered so far are Harappa, Mohenjo-daro, Ganeriwala, Rakhigarhi, Kalibangan, Rupnagar and Lothal.

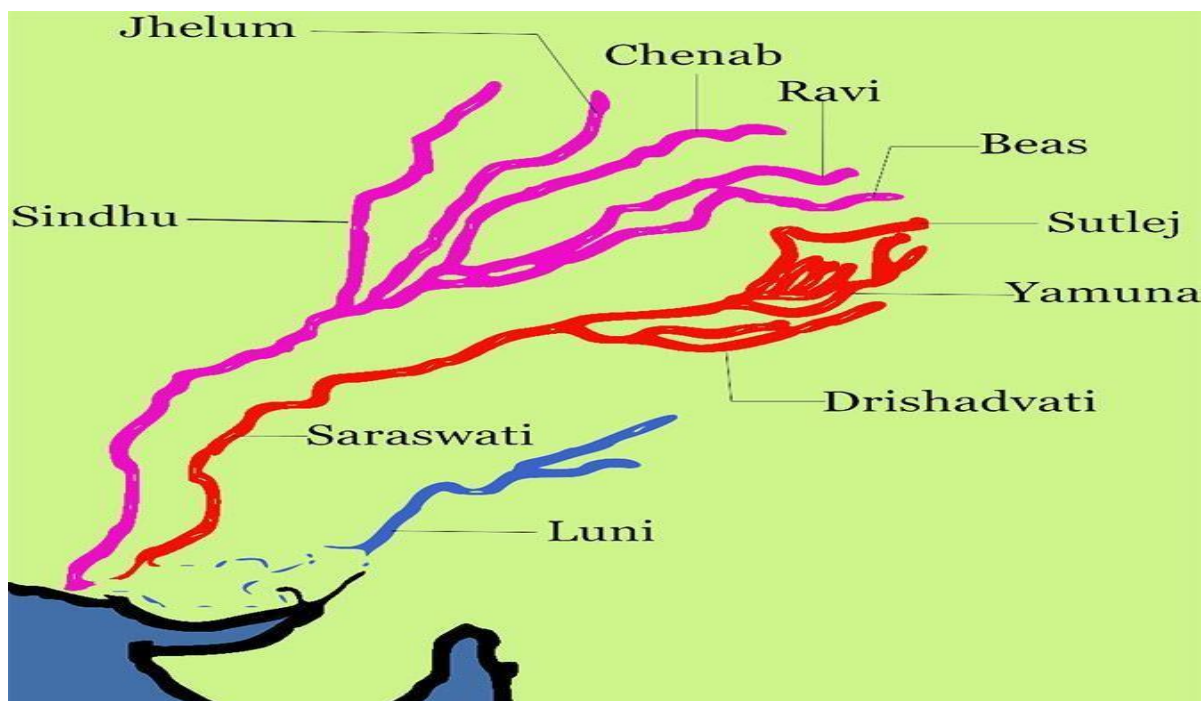


Fig. 5. The Lost River Sarasvati and Now Found

Dholavira depicts the scientific knowledge of water conservation, water reverse voice, step wells in the 3rd millennium BCE. The archaeological excavations during the stage III of the city, due to the drying up of the river drainage system of Sarasvati. Dholavira civilization was engaged in the global trade through river systems for inland navigation and sea to connect the Egyptian and Iraq (Mesopotamia) civilizations. The city had massive reservoirs, three of which are exposed (McIntosh, 2008). Excavation at the site in 2014 began on a rectangular step well which measured 241 feet long, 96 feet wide, and 33 feet deep, making it three times bigger than the Great bath of Mohenjo Daro (Tewari 2014). It is also established that a coastal route existed linking Lothal and Dholavira to Sutkagen Dor on the Makran coast (Singh, 2008). It is possible that the settlement in Dholavira opted to construct a large number of reservoirs, the main stream drainage dried up (Sarasvati) and rivulets on the south and north of the Ancient Cosmopolitan City. Disappearance of the river Sarasvati caused out migration from the ancient city of Dholavira and finally dated to abandonment and decline. Dholavira has a foundry of coin making and Seal making, its own scripts and language massive civil constructions and used the best architecture and defensive structure, that stands till today as remnants. Dholavira's trade links were global. Dholavira spoke an unknown language and their script has not yet been deciphered. Some inscriptions are also found on copper tablets, bronze implements and small objects made of Terracotta stones and faience. Research of IIT Kharagpur Indian Institute of Technology reveals that the decline of Harappan city Dholavira was caused by drying up of rivers like Sarasvati River and Meghalaya drought. These researchers have for the first time connected the decline of Harappan city Dholavira to the disappearance a Himalayan snow fed river which once flowed in the Rann of Kutch. They have also been able to connect the dots between the growth and decline of Dholavira, located in the Rann with this river which resembles the Himalayan River Sarasvati.



Fig. 6. Abandoned Cosmopolitan City Dholavira (Ancient City) Rann of Kutch, Gujarat

Lothal the Southernmost City of Indus Valley Civilization

The city of ancient civilization Lothal, located near Ahmedabad in the state of Gujarat. Construction of the city is believed to have begun around 2200 BCE (Kulke) 2004 according to the Archaeological Survey of India, Lothal had the world's earliest known dock, which connected the city to an ancient course of the Sabarmati River on the trade route. This ancient trade route stretched between Harappan cities in the Sindh (Pakistan) and the peninsula of Saurashtra where the surrounding Kutch desert of Gujarat today was part of the Arabian Sea (Leshnik, 1968) the National Institute of oceanography in Goa had discovered foraminifera (Marine and sea microfossils) and salt, gypsum crystals in the dock site of Dholavira clearly indicates that sea water once filled the structure and it was definitely a dock yard. Lothal was a significant trade Centre in ancient times. The city used to trade with west Asia and Africa. Lothal was an Ancient urban settlement with bricks and stone construction Lothal was linked to Dholavira in the waterways. River Sarasvati, the rivulet that connects Lothal was the rain fed or a Himalayan glaciation fed River system. Another angle of human urban settlements does link every possibility that the step wells in the medieval period were constructed on the river Sarasvati bed areas. The step wells do establish the possibility that the river Sarasvati used to depend on the water supply from the river Sarasvati. Lothal was providing access to the gulf of Khambhat through a river (Rao, 1985).

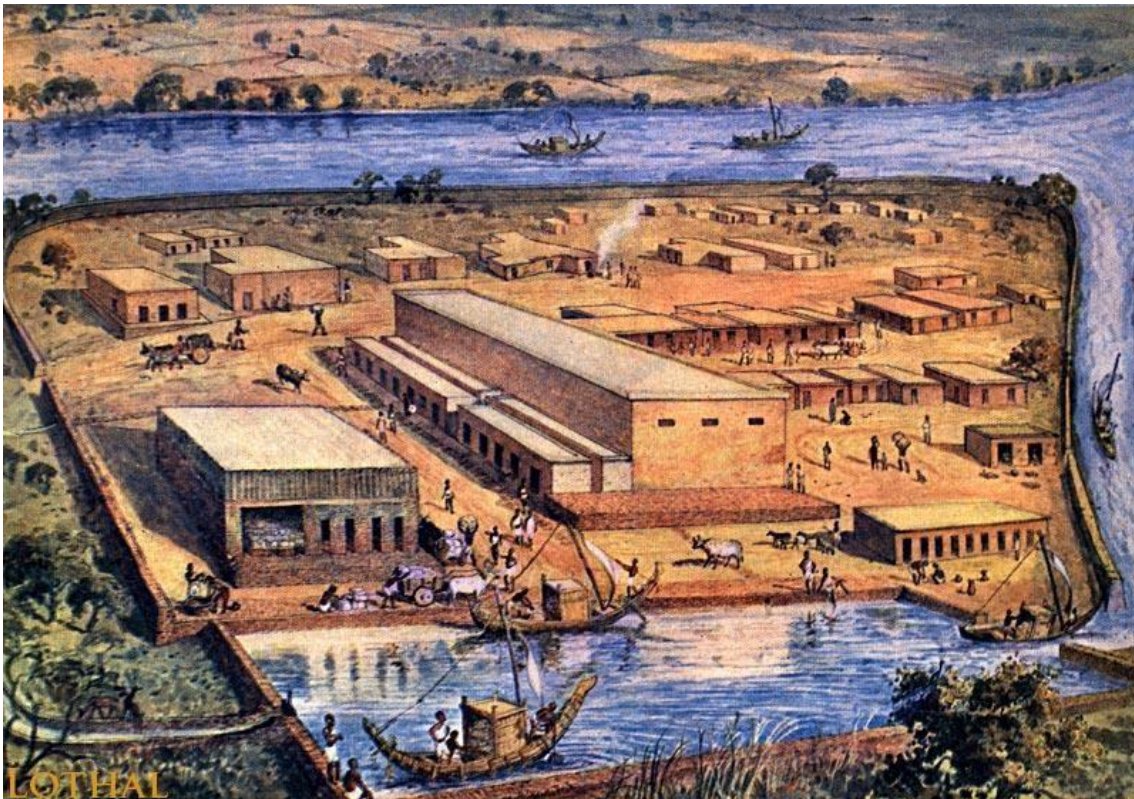


Fig. 7. Ancient Port City Lothal, Gujarat – Died with the disappearance of the River Sarasvati

The beads and gems of Lothal were in great demand in the west. River Sabarmati is a rainfed system with its origin from aravali Range in Rajasthan in the recent years. The river has also dried up. The river had tributaries of the river Sarasvati origin in an early Harappan age and prior to it Lothal port and Lothal dock started declining with shortage of river water and disappearance of the river Sarasvati. Another possibility is that the cause for the abandonment of the city may have been changes in the climate as well as Natural disasters, as suggested by the environmental magnetic records (Khadkikar et al. 2004). Lothal is based upon a mound that was a salt marsh invaded by a tide. Before the Arrival of Harappan people in 3000 BCE, Lothal was a small village next to the river providing access to the mainland from the gulf of Khambhat. The indigenous people maintain a prosperous economy attested by the archaeological excavation and the construction of Dholavira city where fire dried bricks line sand and mortar the indigenous people maintain a prosperous economy attested by the archaeological excavation. The construction of Dholavira city was made of fire dried bricks, lime sand and montan not by sun dried bricks as the bricks are still intact after 4000 years and still bound together with each other with a montan bond. Lothal dockyard and the font were scientifically designed with modern engineering skills and knowledge. Fresh water and drinking water are the lifeline of any Civilization with the disappearance of the river Sarasvati, the supply chain drainage of freshwater disappeared and the decline in phase of the ancient port city Lothal standard. Lothal is an epitome of a lost civilization depending on the Lost rivers Sarasvati.

Rakhigarhi - Ancient Urban City in Haryana

Rakhigarhi archaeological site is located in the Hisan district of Haryana state, about 150 km northwest of Delhi, located in the Ghaggar river plain (Wright, 2009). Rakhigarhi belongs to the Indus Valley civilization. It was among the largest settlements of the ancient civilization. Many sites in the vicinity are still awaiting excavation are Mitathal and Lohari Ragho. Rakhigarhi is located in the Ghaggar plain, some 27 km from the seasonal Ghaggar river. According to Jane McIntosh, Rakhigarhi is located in the valley of the prehistory Drishadvati River (the real root of Vedic River Sarasvati) that originated in Shivalik Hills (McIntosh, 2008). Rakhigarhi was spread over 750 acres encompassing a set of 7 mounds (Nath 2015). Rakhigarhi was the largest town and regional trade centre surrounded by the Ghaggar Hakra River system. There are many other important archaeological sites in this area, in the old river valley to the east of the Ghaggar plain among them are Kalibangan, Kunal, Baln, Bhirrana and Banawali (Nath, Ganga and law, 2014). Different archaeological findings confirm both early Rakhigarhi existence in the early and mature Harappan pages and include 4600 years old human skeleton, fortification and bricks.

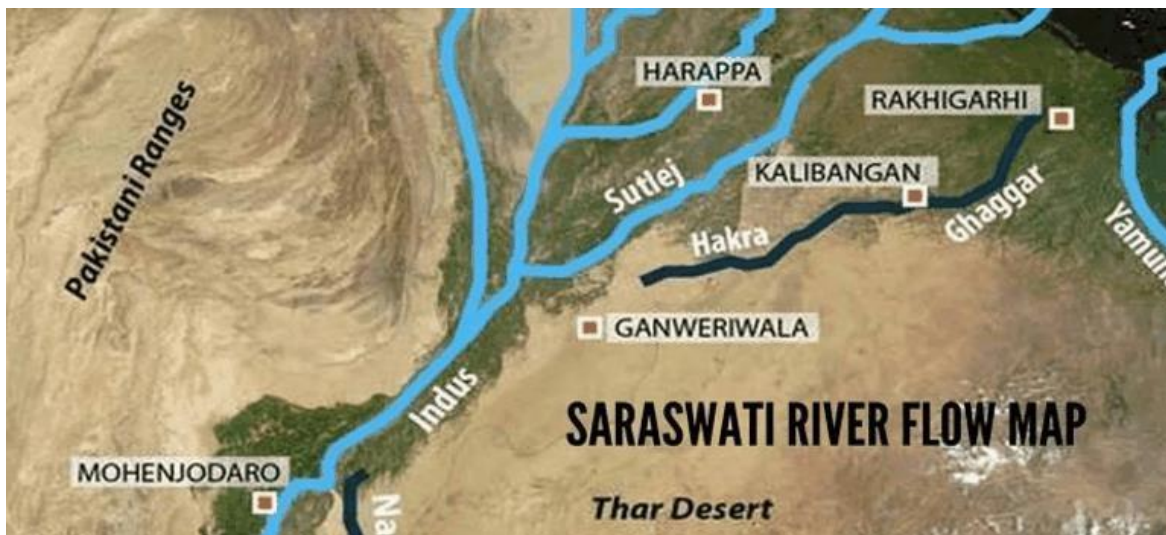


Fig. 8. River Sarasvati flow map (3000 BCE)

The city was a planned urban settlement with a massive granary, drainage system, cemetery and burial sites, planned city structures with nothing less than a modern urban city with the disappearance of the rivers Sarasvati and drying of the river bed. Rakhigarhi urban fortified city started declining. It was the largest Indus Valley Civilization after Mohenjo-Daro. In the nearby vicinity, contemporary to Rakhigarhi were Kunal and Bhirrana. The carbon dating of Bhirrana site revealed that it dated back to 7030 BCE i.e., 9000 years old. Kunal, pre Harappan Indus Valley Civilization settlement is located at a distance of 30 kms from Fatehabad city in Faridabad district of Haryana state. Birhana is also called as Birhana located in a small village in Fatehabad district of Haryana. Bhirrana dates back to 8th-7th millennium BCE. It is one of the many sites seen along the channels of the Ghaggar river i.e., Rigvedic Sarasvati river.



Fig. 9. Ancient Urban Settlement Rakhigarhi (Haryana) abandoned with the disappearance of the River Sarasvati

Topographical Variation of the Region using DEM

The physiographic characteristics of northwest India can be represented on a slope map, revealing a vast expanse of gently sloping terrain from the northeast to the southwest. This region has an elevation range from about 270 meters at the foothills of the Himalayas to the sea level along the Gujarat coast. Numerous streams originate from the southern slopes of the Siwalik Hills, flowing southwest and eventually merging with the Ghaggar River. Apart from the Himalayan foothills, much of northwest India consists of extensive alluvial deposits made up of clay, silt, and sand. The region experiences a hot and dry summer, a southwest monsoon

season, and a cool winter (Raghav 1999). The physiographic features of Rajasthan, Haryana, and Gujarat are detailed below.

Physiographic Divisions of Northwest India

Drilling data from Jaisalmer district in Rajasthan reveals fine to medium and coarse-grained sand and gravel deposits within paleochannels, which were shaped by ancient fluvial activity. Coarser sediments are typically found at depths of 40–125 meters in most tube wells. These channels are approximately 35 to 80 meters thick, with water levels ranging from 35 to 60 meters. In contrast, lithological data from areas close to paleochannels in Haryana show medium to coarse-grained sands, gravel, and pebbles at depths between 10 and 100 meters. Electrical resistivity soundings along the Ghaggar River indicate thick and extensive subsurface sand deposits in parts of northwestern Rajasthan, Haryana, and Punjab. The dimensions of these paleochannels suggest the presence of a large, long-standing fluvial system in this region.

Physiographic Divisions of Rajasthan

Rajasthan is divided into two natural regions. The northwestern part consists of sandy, arid land with scarce water resources, though it becomes more fertile and habitable as one moves eastward. The western part of Rajasthan is characterized by aeolian sands and alluvium deposits in the Thar Desert. In the southwestern region, the landscape includes several hillocks forming part of the Aravalli Mountain range (Gupta et al., 2001). The main physiographic features of Rajasthan include:

Western Sandy Plains

- Sandy Arid Plains (Marusthali)
- Semi-Arid Transitional Plains (Rajasthan Bagar)

Aravalli Range and Hilly Region

- Aravalli Range and Bhorat Plateau
- Northeastern Hilly Region

Eastern Plains

- Banas Basin
- Chappan Plains

Southeastern Rajasthan (Pathar or Harauti Plateau)

- Vindhyan Scarp land
- Deccan Lava Trap

Physiographic Divisions of Haryana

Haryana's landscape is divided into four major physiographic features which includes **Siwalik Hills** altitudes range from 900 to 2300 meters, and these hills serve as the source for rivers such as the Sarasvati, Ghaggar, Dangri, and Markanda. **Ghaggar-Yamuna Plains** area is split into two parts: the higher 'Bhangar' and the lower 'Khadar'. These alluvial plains consist of sand and calcareous gravel balls, locally known as 'Kankar'. **Semi-Desert Sandy Plain** Bordering Rajasthan region includes the districts of Sirsa, parts of Fatehabad, Hisar, Bhiwani, and Mahendragarh. **Aravalli Hills** is a dry region with an uneven and irregular landscape (Bhadra et al., 2006).

Physiographic Divisions of Gujarat

Gujarat's physiographic features are divided into several distinct regions: **Coastal Zone** located in the southern part of the state. **Kachchh Mainland** comprising the central part of the state, it consists of rocky terrain with hills in the north and coastal plains. **Banani Plains** characterized by fluviomarine sediments, this region features mudflats and soft pans. **The Two Ranns** then are The Great Rann in the north and the Little Rann in the east, both consisting of vast saline wastelands (Bhadra et al., 2009).

Drainage System of Northwest India

Several thousand years ago, the north western part of India was drained by a network of mighty rivers. However, these river systems have been largely disrupted, with many either destroyed or preserved only as remnants, forming the present-day drainage patterns. While the Himalayan rivers continue to nourish the Indo-Gangetic plains, southwest Haryana, southern Punjab, and western Rajasthan remain riverless. These regions are covered by a 10–30-meter-thick layer of younger riverine sediments, characterized by numerous channels that carry floodwaters only briefly. Many of these channels are now filled with sediments or buried under the sands of the Thar Desert (Raghav, 1999).

The presence of numerous archaeological sites along the palaeochannels of the Sarasvati basin highlights the strong connection between the Indus-Sarasvati (Harappan) civilization and the ancient Vedic Sarasvati River. The spatial arrangement of Early, Mature, and Late Harappan settlements in Haryana suggests a gradual

migration of populations from the southwest to the northeast, corresponding to the progressive drying of the Saraswati River (Gaur et al., 2005).

Disappearance of River Saraswati:

The Saraswati River system in the Vedic period includes the rivers Ghaggar, Markanda, Chautang, Sutlej and Yamuna. The diversion of the Sutlej and Yamuna is considered as the main cause of loss of River Saraswati by most of the researchers. The rivers Ghaggar, Markanda, Saraswati and the Chautang rise in the Siwalik Hills. Different scholars attempted to establish chronological sequence of events that contributed to the desiccation of Vedic Saraswati. Their compiled works are based on different aspects like climate, tectonism, drainage changes and cultural events which can be combined for the purpose of evaluating the changes in the drainage systems of northwestern India. In turn, it throws light on the events that have contributed to the decline and final loss of river Saraswati (Valdiya, 2000).

Late Quaternary tectonism in combination with the sudden increase in aridity related aeolian activity disrupted and obliterated the courses of the rivers of NW India mainly the Saraswati River. From the studies by the various eminent researchers for the past several years now it has been clear that the Yamuna as well as the Sutlej were tributaries of the Saraswati River. Around 3700 B.C tectonic disturbances in the area have caused the capture of upper catchment water of Saraswati by Yamuna and westward migration of Sutlej causing the drying up of the river (Oldham 1886).

Over a 3000-year long period since the Vedic times, the drainage pattern of many rivers had changed from that described in the earlier religious literatures. The decline of Saraswati appears to have commenced between 5000–3000 B.C. probably precipitated by a major tectonic event in the Siwalik Hills of Sirmur region. Geologic studies indicate destabilizing tectonic events in the entire Siwalik domain extending from Potwar in Pakistan to Assam in India resulting in massive landslides and avalanches. These disturbances, which continued intermittently, were all linked to uplift of the Himalayas. One of these events must have severed the glacier connection and cut off the supply of glacier melt-waters to this river. As a result, Saraswati became non-perennial and dependent on monsoon rains. All its majesty and splendour of the Vedic period dwindled with the loss of its tributaries and the river totally got lost around 3000 B.C. (Radhakrishna 1998).

Saraswati was totally lost when its water was captured by the Sutlej and the Yamuna. Thus, climatic changes and geotectonic movements have led to the migration and abandonment of several rivers and drainage systems. The cumulative effect of reactivation of Yamuna tears constriction of catchment area of Vedic Saraswati by emergence and migration of river Drishadvati. Views of some important authors have been highlighted here (Oldham 1886).

The researchers suggested the following causes for Saraswati migration and drainage desiccation in NW India. The following are the possible reasons for migration and loss of Saraswati River:

- Rise of Delhi-Haridwar ridge along the NE-SW lineaments.
- Rise of Aravalli hills bounded by lineaments on its west.
- 6. Stream piracy by the rivers like Yamuna and Beas.
- Climate change from wet to dry spell, as evidenced by geomorphological and stratigraphic records during the Quaternary period.
- Neo-tectonic changes in the Himalayan and Aravalli regions.
- Uplift of Himalayas and Siwaliks
- Uplift of Aravalli range resulting in northward shift of river Saraswati.
- River piracy of Saraswati and subordinate rivers by Yamuna, Satluj, and Ganga.
- Climatic changes from humid to desertic conditions.
- Changes in glaciation in Himalayas.
- Choking of rivers by enormous sand debris.

Settlements on River Saraswati:

Paleontological studies of Rajasthani lakes show that the climate was unsuitable for human survival prior to 8000 BC, that there was a high rainfall between 8000 and 7500 BC, a slight decrease in rainfall between 7500 and 3000 BC, and a brief dry spell between 3000 and 1000 BC. Based on these findings, we can conclude that the climate in the Saraswati bed would be suitable for human settlement after 7500 BC. The pre-Harappan features of Kalibangan, located in the Hanumangarh District of Rajasthan on the left bank of the Ghaggar River, include fortified houses made of mud bricks, pre-Harappan type pottery, and ploughed fields. The mature Harappan features, such as houses with baked bricks, terracotta, and a citadel on the west side of the houses, were dated between 5600BC and 2700BC based on radiological findings, indicating that the culture there was pre-Harappan. Just 10 kilometers from the Nohar railway station in Rajasthan's Hanumangarh District, the

excavation at Sothi displays pre-Harappan elements such as mud or brick homes, pottery, and village culture, as well as Harappan elements like terracotta, cartwheels, round cakes, and bangles. Radiological data indicates that the culture was active between 5600 BC and 2192 BC. The archeological site of Siswal, located in the Hissar region of Haryana, yielded blades and copper artifacts utilized in mature Harappan culture, as well as colored ceramics similar to those found in Kalibangan and mud-houses that revealed pre-Harappan culture (Nigam, R. 2012). On the bank of Saraswati in the Fatehabad district of Haryana, Banawali is another excavation site where pre-Harappan (sun-dried bricks, mud walls in homes, painted motifs) and mature Harappan (fortification towards the north, baked bricks) may be found. Located in the Kaithal District of Haryana, 2 km north of Balu Village, the excavation site Balu exhibits post-Harappan culture through the usage of mud and brick constructions, brick platforms, kilns, furnaces, beads, shell bangles, and copper artifacts. Rakhigarhi, situated in the Tehsil-Hansi district of Haryana on the banks of the Saraswati and Drishadvati rivers, exhibits a drainage system, circular pits, a fire chamber, arrowheads made of metal, copper bangles, toy carts, and steatite beads, all of which are examples of pre-Harappan objects; post-Harappan items include blades, terracotta, shell bangles, semi-precious stone beads, copper objects, animal figurines, toy cart frame, bone points, and steatite seals. Excavation site Kunal, found in Fatehabad district of Haryana, shows pre-Harappan culture which as per radiological data was dated back to 3016 BCE-2577 BCE. In this site, the pre-Harappan settlers dug up large pits over which wattle-and-daub huts were raised and they used agriculture and domestic animals, bone-tools, micro-blades of chalcedony, copper arrow-heads and fish-hooks; the mature Harappan settlers used moulded mud-bricks as in Kalibangan and Banawali, and dwelling pits; and the post-Harappan settlers constructed rectangular and square houses, terracotta, shell seals, crowns, armlets, bangles and necklace of silver, six gold beads. Bhirrana, which is located in Fatehabad district of Haryana. Other characteristics of the mature Harappan period included mud walls, baked bricks, steatite beads, pottery assemblages, city layout, and fortification. Ganeshwar is an excavation site in Rajasthan's Sikar District that has pre-Harappan artifacts from 3800 BC to 2000 BC (Nigam, R. 2012). The pre-Harappan period included chert tools for hunting and gathering, mud homes, and sun-dried bricks; mature Harappan men left behind copper metal works, fired clay pottery, city layout, drainage systems, and copper bangles. Among the most notable post-Harappan traits observed here were urban culture and the widespread use of copper items. Pre-Harappan dwellings consisting of wattle and daub were discovered at the Baror excavation site in Rajasthan's Sri Ganganagar District, indicating the early Harappan civilization there. Ploughed fields, blades, and pottery were unearthed from the excavation sites in North Gujarat, revealing a fully developed Harappan culture there all at once. Pottery, animal skeletons, steatite micro-beads, shell and semi-precious beads, terracotta items, and lumps of burnt clay—the primary items used by pre-Harappan man—were discovered during an excavation at Lotheshwar in Gujarat's Patan district. The remains of Early Harappan man's copper blades, mud homes, bowls, black-painted pots, and hand-made wheels were found at the Padri excavation in Gujarat's Bhavnagar District. There are excavation sites in the Mewar region of Rajasthan where artifacts from a time before the pre-Harappan period were found. These sites were mostly utilized for rudimentary farming and community life (Gaur, et al., 2005).

The Saraswati-Ghaggar Rivers were perennial in northern Rajasthan during the pre-Harappan and mature Harappan periods, and they have since reduced to a small stream, indicating that the river was receiving less water and gradually drying up. Archaeologists have discovered numerous excavation sites in the bed of the extinct Hakra-Saraswati-Ghaggar system and their extinct tributaries. Numerous protohistoric sites can be located along the route of the defunct Saraswati system, particularly between Hanumangarh in India and Bahawalpur in Pakistan. (Gaur, et al., 2005). Kalibangan, Sothi, Banawali, Rakhigarhi, Kunal, Bhirrana, Baror, Grawad, and Ganeshwar excavation sites were used to study pre-Harappan features. This suggests that human settlements may have existed in these locations between 4500 and 3000 BC. The presence of human settlements during the mature Harappan period in each of these regions demonstrated that human settlements existed from the early 3000 BC to the 1800 BC. Only post-Harappan artifacts were excavated in Balu since human settlement was restarted after 1800 BC and 1600 BC. Based on the findings, we can conclude that the transition from pit dwelling to ground dwelling took place around this time. Neolithic man bones were also found at this location, demonstrating that early humans survived between 7500 and 6000 BC. Based on radiological evidence, Mortimer Wheeler claims that the Harappan society existed between 2350 and 1700 BC, rather than 3000 BC as Marshall claimed. However, in the Saraswati bed, human culture predates the Harappan culture. As a result, it is believed that the human culture in the Saraswati bed was very different from the Harappan society and more like the Vedic culture (Bhadra, et al., 2009).

Stepwells and Rivulets on the Rivers Saraswati Source

River Saraswati was the life line of many advanced urban settlements of the ancient period. After the disappearance of the river Saraswati many civil engineering methods were used by the ancient Civilization to store the water and to connect drainages to have water supplies. Step wells are constructed in areas where water is scarce. There were many times constructed on trade routes to facilitate the needs of travellers. The well

digging and the construction of the step wells followed the Civil engineering principles of underground water streams and the community of well diggers in many regions in western India were well versed with the knowledge of existence of underground streams and also the techniques of well - digging. Some step wells are multi- storeyed and can be accessed by the pension wheel which is pulled by a bull to bring water to the first or second floor. The earliest evidence of step wells is found at Dholavira where the site also has water tanks or reservoirs with flights and steps. The earliest evidence of step wells has reference in Asokan pillar edict No. 7, the first rock cut step wells in India date from 200 to 400 ADE (Livingston, 2002) some of the prominent step wells are available in Patan, Junagarh, Gandhinagar and Ahmedabad. Many rivulets were constructed and dug by the inhabitants of ancient settlements, fortified urban townships in the arid zone, Rann of Kutch, desert and in the arid zone of the Rajasthan, Delhi and Haryana region. Some of the rivulets are natural in India but many are wide canals for the inland navigation voyage ships anchorage. Many rivulets were dug on the river Sarasvati to bring the water to the Harappan period ancient settlement Dholavira, Lothal, Rakhigarhi and other ancient settlements.

Rani Ki Vav Step Well in Patan

The queen's step well is locally known as Rani ki vav in Gujarati language, located in Patan district of Gujarat. This step well was constructed by queen Udayamati of Bhima in the 11th century ADE. Rani ki vav was constructed during the rule of Chalukya Dynasty, on the area of the Sarasvati River. This city was plundered and sacked by Qutb-ud-din Aybak and Allaudin Khilji the Islamic Delhi Sultanate in the 12th and 13 century ADE (Lal, 1950). The step well was commissioned in 1063 ADE and was completed after 20 years. The step well was later flooded by the Sarasvati River and silted over (Tomar and Faruqi, 2018). The step well is designed as an underground shrine or invented temple, this represents the sanctity of water. There are a large number of celestial beings (Apsaras) Rani ki vav, on the bank of Sarasvati River, was initially built and a memorial Rani ki vav is an expansion example of distinctive forms of subterranean water architecture of India. Subcontinent, the step well which is located on the river bed of Sarasvati. This step well was built to provide drinking water to the nearby village settlements in Patan Rani ki vav in a UNESCO World Heritage site due to its stone architecture. Step wells in India were the permanent water source in these arid lands, ensuring water availability during times of drought. In Indian beliefs it's Holy to get access to the river Sarasvati water. River Sarasvati is treated holy in the Hindu, Jain, and Buddhist faith. Apart from being a UNESCO World Heritage site, Rani ki vav has been declared a monument of national importance. The step well is 98 feet deep with 7 levels of stairs. There are more than 500 principal sculptures and over a thousand minor ones. This is a Marvel of civil engineering in bringing the dried river bed water to the surface (Mehta & Bhatt, 2014).

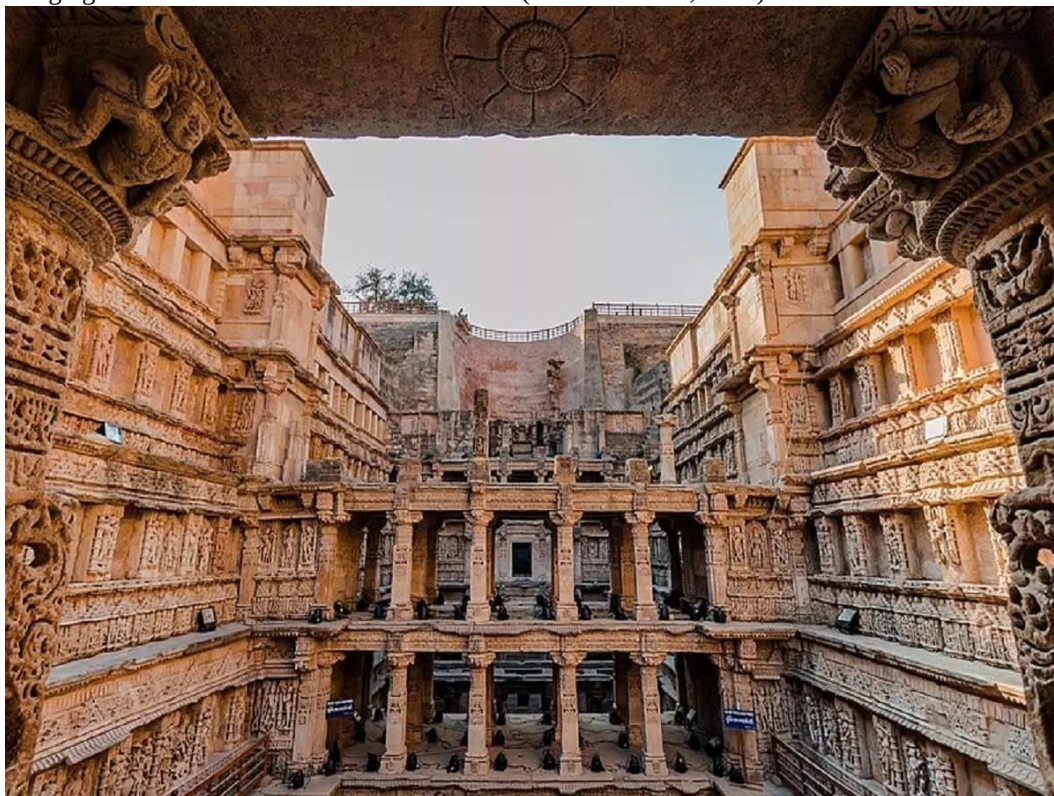


Fig. 10. Rani Ki Vav (Stepwell) on the River Sarasvati Bed, Patan District, Gujarat, India

Adalaj Step Well or Rudabai Stepwell, Gandhinagar

The step well is located in Adalaj near Gandhinagar. Step wells were once integral and highly essential to the semi-arid regions of Gujarat, as they provided water for drinking, washing, and bathing. These step wells were also venues for colourful festivals and sacred rituals. (Takerawa, 2002) step wells as stepped ponds, built between 5th and 19th centuries ADE, are common in western India. Gujarat state hosts more than 120 such step wells in the past that were frequently used by travellers and caravans as stopovers along trade routes (Takerawa, 2002). Ancient and medieval step wells survived so long in Gujarat because of the builder's knowledge of the soil conditions and the earthquake proneness of the region (Livingston, 2002). There is every possibility that Adalaj stepwell is located on the ancient disappeared river Sarasvati bed. River Sabarmati was a later period river. Adalaj was well connected with Lothal trade city of the ancient world. The Adalaj stepwell or "Vav", is intricately carved and five stories deep. This was built in 1498 ADE. The stepwell was built in sandstone in the Solanki architectural style.



Fig. 11. Adalaj Stepwell, Ahmedabad (On the Disappeared River Bed)

Other Stepwells on the River Sarasvati Bed

Some of the noted step wells on the river Sarasvati bed are Mata Bhawani's stepwell, Dada Harir stepwell, Jethabhai's stepwell etc. in the Ahmedabad district of Gujarat. Mata Bhavani in Asarwa area of Ahmedabad was built in the 11th century ADE during Chalukya dynasty rule in Gujarat with the funding of overseas traders and maritime merchants. The stepwell was built much before the establishment of the modern city Ahmedabad. This multi-story stepwell has open pavilions positioned along the east-west axis (Tadgell, 1990) this stepwell has three stories and three pavilions. The diameter of the well is 4.8 meters (Jutta Jain, 1981). The stepwell is 46 meters long and 5.1 meter wide at its entrance.

Another stepwell on the river bed of Sarasvati is Dada Harir stepwell in Asarwa area of Ahmedabad district 15 kilometres off of the city Ahmedabad. Dada Harir stepwell was built in 1485 ADE (Gargette, 1879). The stepwell was built in sandstone in Solanki architecture style with five stories deep. The well has five levels. At the level of the ground it is 190 feet long and forty feet wide. In the vicinity there were several step wells, closed and not used. The river Sarasvati bed leaves the underground water source for use and in future to revive if possible, next to impossible.

Jethabhai stepwell was built in 180 ADE with four pavilions and one entrance pavilions in the Isanpur area of Ahmedabad district (Kumar, 2008). This stepwell was an ancient monument but was destroyed and rebuilt by the Islamic power by the old stepwell. Step wells in and around Ahmedabad and Gandhinagar districts are built on the disappeared river Sarasvati bed. This stepwell is restored by the archaeological survey of India.

Impossible Revival of the River Sarasvati

The revival of the ancient river Sarasvati, considered as the holy river of India, has been on the agenda of the state governments and the community at large. Reviving the river that has disappeared around 3500 BCE by

sabotaging many advanced civilizations sacred by more than one billion population of India's, Sarasvati is one among the trio of India's holy river Sarasvati disappeared due to tectonic disturbances, impacting its tributaries. The glacier source of the river shifted its location causing no water supply to the river course. At present the river bed is not dry, the step wells provide the vivid evidence. Claims have been made that the river is alive and flowing underground. The Sarasvati River system in the vedic period included rivers like Ghaggar, Hakra, Markanda, Chantang and Yamuna. In 2018 proposal of the revival of Sarasvati River was considered by the ministry of environment forest and climate changes (MOEFCC) Expert Appraisal Committee (EAC) for river valley and hydroelectric project, in its meeting on May 27, 2019. Sarasvati River is a heritage project with additional benefits like, ground water recharge, flood control, fish farming and recreation / tourism. With reference to a MOU (Memorandum of Understanding) in 2022 between government of Haryana and Himachal Pradesh for construction of Adi Badri dam on the river Somb in Himachal Pradesh. Along with its linkages with Sarasvati River. Storage in Adi Badri dam shall be primarily used for revival of river Sarasvati and development of Sarasvati heritages (PIB 2022). Also, Sarasvati heritages development board had been constituted by the government of Haryana for rejuvenating of Sarasvati River and development. Delineation and mapping of the paleo channels of Sarasvati River has been carried out by Indian space research organisation (ISRO). On the basis of revenue record alignment of Sarasvati River and its tributaries in about 200 kilometres stretch from Adi Badri, Haryana to Ghaggar, Punjab has been identified. The discovered river course has been validated by a variety of scientific data and investigation carried out by various survey agencies. In another research it has been identified that the glacier feeding the Sarasvati River was located on the Siwalik range of the Himalayas. In another mountain engineering theory, glaciers located on the Siwalik ranges of Himalaya are subject to frequency shifting. The Sarasvati River flowed through the plains of Haryana, passed through the Thar - Cholistan desert of Rajasthan and eastern Sindh, running roughly parallel to the Indus river and then reached the sea in the Rann of Kutch in Gujarat state (Bhadra et al. 2000) in 2016, Sarasvati Heritage Development Board (SHDB) conducted a trial run by filling the river bed with 100 Cusecs of water which was pumped into a dug-up channel near Yamunanagar. The Sarasvati River project seeks to build channels and dams along the route of the lost river (ZMB, 2016).

Conclusion and Recommendation:

The river Sarasvati can be brought back to life as a perennially flowing river by recharging the river bed through rain water harvesting, supplying water from other drainage sources, having dams at the required distances and creating reservoirs on the river beds and the river course. Rejuvenation of the river is possible at a huge cost and expenses with the marvels of water engineering. In fact, it is true to say that, it is impossible to revive the lost river to flow again. One prominent warning, with the climate changes the glacier fed rivers in future will dry like Sarasvati River. Most of the rivers flowing down the Himalayas are highly susceptible to climate change impacts. River Sarasvati may be brought back to a flowing stream like a river, but the tributaries and distributaries cannot be recharged. Rivulet, man-made and naturally linked with the river Sarasvati will remain dry. The river Sarasvati bed needs to be treated with poly layers to prevent water slippage, side wall construction demand turns into a mandatory feature to keep the water level constant in the total drainage process. The river will look like a flowing channel in its appearance. Such a recovery of the lost river as a revived one will attract greater attention for further research in developing new engineering concepts for other rivers susceptible to climate change and climate threats. A pessimistic view, the mountain glacier fed rivers will dry within a span of over a hundred years. The revival and restoration of the dead rivers need localized plans and engineering. No universal water engineering can be provided for all dried rivers to recover. Hydrology and irrigation engineering as traditional technology has to come out and redesign different strategies and engineering solutions for the drainage system. Satellite images and scanning systems have been proved fruitful in the context of the river Sarasvati. The river Sarasvati revival from a disappeared river to a live river will leave great lessons for mankind.

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Study of the Collaboration of the Indian Medical Devices Industry with the Academia

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Abstract

The article starts with a short introduction to the Indian medical device sector. Though the sector's growth is three times higher than the world market's growth, a critical issue is its heavy dependence on imports mainly due to a lack of focus on R&D and new product development where collaborations between the industry and academia can be of significance. In India, the industry-academia collaboration situation has not been studied well. Some of such collaborations abroad in the same sector are summarised in the article. The study was planned to deep-dive into the incidence, objectives and tactics of the medical devices industry by interviewing senior managers about the industry-academia relationship, through a descriptive study adopting both quantitative and qualitative approaches. The top executives of 64 medical device companies were interviewed for this study. Data analysis, word frequency, word cloud, and interview comments are used to study the industry's approach to industry-academia collaborations. The frequency of serious industry-academia collaborations was less than one-third for the companies interviewed across the size, the life and the types of companies. The major objectives from the industry side for such collaborations were to gain specialized knowledge and to obtain ready products as mentioned by the respondents with active collaborations. A similar pattern was revealed in Qualitative analysis also. This smaller number of companies engaged in collaboration with academia may be an area of attention for policymakers. The industry has found some innovative and ingenious models for successful collaborations. Many interview comments indicate that barriers like past experiences, trust deficit and bureaucracy in academia may be possible hindrance. The Triple Helix model addressing the barriers between the industry and academia is also discussed. The data indicates that the barriers between the industry and academia are the issues falling under the sub-theme of "Relationship" barriers as per this model. Though there is a need and good scope for industry-academia collaborations for medical device development, some course corrections may be helpful.

Keywords: Medical devices development, industry-academia collaborations, models, barriers

Introduction

India is one of the twenty largest markets in the world for medical devices and is the fourth largest in Asia (KPMG, 2022). India represents 1.65 % of the global market of devices. India has about 750 – 800 Medical Devices manufacturers as per various industry data sources (Informa Market, 2020; Department of Pharmaceuticals, Ministry of Chemicals & Fertilizers, Government of India, February 2021). The size of the medical devices sector in India is 11 bn as estimated by India Brand Equity Foundation (2023). KPMG (2022) estimated the sector size to be 12 bn USD and also mentioned that the industry is fragmented, with almost 95% of manufacturers being small or medium-level enterprises. The more significant feature of the sector is its growth rate. While the world growth rate for the sector is slightly above 5 %, the estimated growth rate for the Indian medical device industry is 16.4%, three times higher. Disposable medical devices are the major products manufactured in India, and these include complex disposables like vascular stents, intraocular lenses besides ortho implants (India Brand Equity Foundation, 2023). Population growth and higher life expectancy, along with better health awareness and higher spending on health – both public and private – are the factors driving higher growth (KPMG, 2022). The prevalence of chronic diseases also contributes to higher spending. Prevalence of CVS, respiratory diseases and cancer have been noted by the Foundation for MSME Clusters (2023).

The challenge for the Indian medical devices sector is its very high dependence on Imports. Import dependence of India is estimated to be 70 to 80 % by India Brand Equity Foundation (2023). In the Indian market, top-end high-value spaces like electronic equipment are possessed by MNCs, mainly through imports, and this may not change in the short run, and import dependence on those companies may not stop (EEPC India, 2013; KPMG, 2022). In the year 2022, device imports grew by 41%, making 63,200 cr imports during 2021-22, from Rs 44,708 crore in the previous year, quoted Mr Rajiv Nath, Forum Coordinator, Association of Indian Medical Device Industry (AiMeD) based on the data of the Ministry of Commerce and Industry, India (BioSpectrum, 2022).

Literature review

R&D – A differentiator

KPMG, in its report, gave a clear insight into the possible reason of the import dependence of India for medical devices. The report stated that the value chain for medical devices has four clear activities: Research and product development, Complex manufacturing, Assembly and simple operations, and Packing & distribution. Exporting countries are involved in the first two activities, while India is at the receiving end due to a lack of new product development and research. Other countries, like Vietnam and Mexico, are also in the same situation, doing packing and distribution activities (KPMG, 2022). R&D and new product development are clear differentiators. An interesting case study of Stryker, now amongst the top ten global medical device companies proves the same point, again. John Brown took over Stryker when this company was involved in routine products, without any speciality, like emergency room stretchers and instruments for the operation theatre. From USD 17 million in sales, Stryker reached the level of USD 4.5 billion company under the leadership of John Brown changing the focus of the company to new product development. Stryker acquired a company with research scientists and this was a turning point. Stryker then designed a unique innovative hip orthopaedic design called a UHR. This product had no competition in the market creating a niche for the company. Many more ortho implants were later developed by Stryker making it one of the largest and most important orthopaedic companies in the world. The strategy of John Brown was to bring 20 % profit growth from new products (Brown, 2007; Evans, 2016). This case study again proves the importance of R&D focus for medical device companies.

The complexity of medical device development and the need for academic collaboration

Kahn (1991), in his early notes on the comparison between medicines and medical devices, stated a point clearly that devices involve a wide variety of technologies, unlike medicines, and need collaborative efforts. Requirements of convenience, suitability of use, and ergonomics increase the complexity of device development as user convenience is an important aspect of medical devices, unlike a medicine formulation (Martin, Norris, Murphy & Crowe, 2008). Limited in-house knowledge with the medical device companies may not be sufficient for the innovation because of these complex needs bringing the importance of the role of industry-academia collaboration. Gaining knowledge through many models, mainly university-industry collaboration, is an effective method for acquiring the latest knowledge. Such industry-academia collaboration can be an effective method for innovative technologies, solutions to specific issues, newer technology acquisitions, and access to experts & specialised team members (Chung, Ko & Yoon, 2021). Chen, Pickett, Langell, Trane, Charlesworth, Loken, Lombardo, & Langell (2016) noted, from their experience of developing a technology for cervical cancer, that a well-structured academic-industry collaboration may accelerate development in the field of medical technology. WHO has also documented and suggested the members for the right national strategies for the management of health technologies with a recommendation for collaborating with people involved in technology assessment (World Health Organization, 2017).

Case studies for Industry-Academia Collaboration

A success story of industry-academia collaboration in Finland has been described in great detail by Lester & Sotarauta (2007). Known as “The Oulu Phenomenon”, as the case involved a town called Oulu, the authors detailed the cases of hospital technology, telemedicine, healthcare technology and wellness medical device technology through industry-academia partnership through formal and informal meetings. A good number of managers involved said that the local university was an important academic partner in reducing the timeline for new product development and increasing competitiveness.

One more case, known as the Hamamatsu method (because of a town called Hamamatsu in south-central Japan, which was used as a testing ground) is also a success story. AMED, the Agency for Medical Research and Development in Japan, used a model involving Commercial Coordinators (CDs) for educating, matching requirements of both sides, coordinating budgets and funds, and supporting technology transfer. Success lessons and complications encountered in this model using Commercial Coordinators have been described in this case study (Yuko, 2020). Tsuruya, Kawashima, Shiozuka & Nakanishi (2018) have given a very detailed explanation of the development of academia-industry collaborations in Japan starting with such process from the 12th century till recent times. It will be clear from that detailed account that the collaborative culture is a process and not an endpoint. A simple method for initiating collaboration among industry, academia, and government is to organize a workshop involving these parties as per Linehan & Chaney (2010).

CAREFOR forum for healthcare-related industry-academia collaborations is explained in detail by Stahel, Lacombe, Cardoso, Casali, Negrouk, Marais, Hiltbrunner, Vyas, & Clinical Academic Cancer Research Forum (CAREFOR) (2020). Bench-to-bedside competition by the University of Utah, an annual program, described by Chen, et al (2016) was a simple way of encouraging the process of innovation through industry-academic

partnerships. The Balanced Scorecard (BSC), a tool for evaluating business progress, was proposed for use as a strategic success measurement tool for industry-academia collaborations by Al-Ashaab, Flores, Doultsinou & Magyar (2011). In India, Siemens Healthineers has also developed a collaboration model entering into tie-ups with academic institutes and hospitals (Press release by MeitY, 2023).

Research need

A very detailed and exhaustive work has been done by Rybníček & Königgruber (2019) on industry-university (that is, academia) collaboration. They mentioned that much less than expected research has happened on the subject of such collaborations. They did a fairly detailed analysis of the published work on industry-academia collaborations. Their study noted that while reasonable work has been done on this subject in the USA, UK and some other European countries, this subject is not covered much in India, and they could find only one good article worthy of covering in their study on this topic. More research work on this subject is the need of an hour due to this reason (Rybníček & Königgruber, 2019). The area of medical devices for such collaborations was chosen because collaborations of this type are more relevant due to the complexity of the development here, as explained earlier.

Research Questions

The study aims to find the answers to the following research questions-

- What is the extent of the industry-academia collaboration in India in the medical device sector?
- What are the primary objectives of such collaborations for the industry? What is the industry looking for, from such collaborations?
- What are the possible barriers in such relationships?

Research Objectives

The research objectives for this study are to understand in some detail the level and dynamics of the industry-academia collaboration by studying the views of the industry side by interviewing the senior people heading their medical device companies. The study also aims to get an idea of the models being followed for such collaborations, by interviewing the respondents. The study also plans to get an idea of the possible reasons and possible barriers for not going for such collaborations. The study plans to cover the industry side of the processes of industry-academia collaboration by interviewing industry representatives.

General Hypothesis

H₁: There is no significant association between industry-academia collaboration and the new product developments in the medical devices sector in India.

Research methodology and sampling design

The primary focus of the study is to understand the prevalence, objectives and approach of the medical devices industry representatives towards industry-academia relationship. A descriptive research design, which allows more flexibility, was selected. Flexibility and freedom to quantify the numbers are also provided by the descriptive study design. The study used both quantitative and qualitative methods.

A convenience sampling method was used. Both Informa Market (2020) and KPMG (2022) reported that there are about 750 – 800 local Medical Devices manufacturers in India. A complete list of these companies is not available from any data source. The Interview method was selected for the study, and 60 valid interviews were planned. The final number came to 64 interviews, after deducting a few rejected interviews, where the rejection was mainly due to inconsistent data.

A fairly detailed profiles of the companies were gathered from the databases, and their web pages and also by rechecking the data with the respondents, for correlating this data with the responses. A preliminary communication was sent to all the possible respondents through mail or WhatsApp, and the purpose of the interview was explained in detail. After their initial positive response, a convenient time was fixed for a longer conversation with the right person. A very senior person or a promoter/owner-level person who can tell correct information on the R&D models or collaboration practices would be the right respondent, and so, contact with such a person was ensured. The interviews were recorded for qualitative analysis, besides noting down key data during the ongoing interview.

Results

Quantitative analysis

It was found that 31% of the companies (20 companies out of 64, or less than one-third companies) interviewed, had some meaningful and active collaboration with the academic institutes in one form or the other. This was across the size of the companies, the life of the companies and the types of products. The only observation was that such collaborations were prevalent with the companies that had an investment in R&D of more than 5% of their turnover. In other words, the companies focusing on new product development have higher tendency to do a collaboration with academia. Figure 1, below, represents these results in a graphical form.

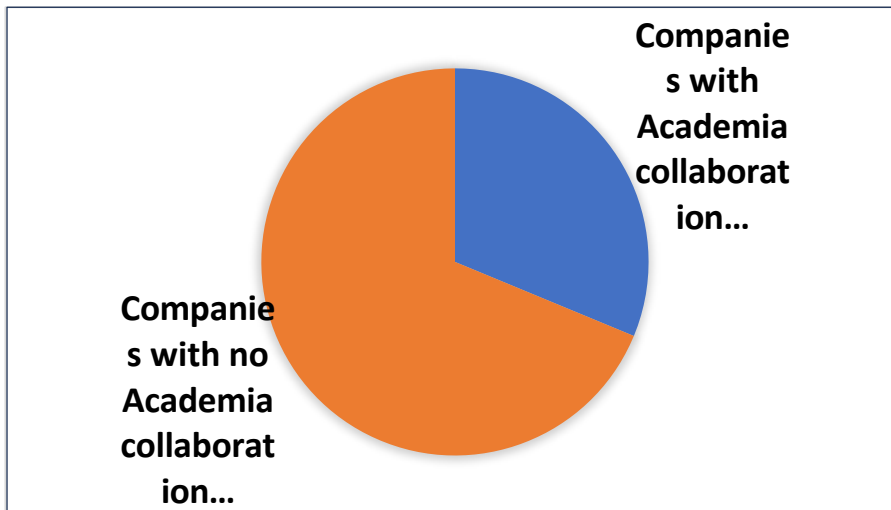


Figure 1 : Frequency of collaborations with academia among the companies (Source: Interviews)

The Tree map chart (Figure 2) represents a good total picture of “Why an Academic Collaboration” – the primary reasons stated by the respondents. The chart summarises the primary reasons behind Academic collaboration.

Seeking specialized knowledge was the number one reason for a collaboration with an academic institute. The companies are looking for specialized knowledge from academia due to the complexity and variety of the devices. Ready product (3 out of 20), Protocol testing (3 out of 20), Clinical trials (2 out of 20) and Training (1 out of 20) are other expectations from these educational institutes. “Specialized knowledge” and “Ready products” out of the total respondents as visually clearer reasons for collaborations in Figure 2.

The major reasons for not having collaboration was “No Need” or “Past Experience”. This needs to be noted.

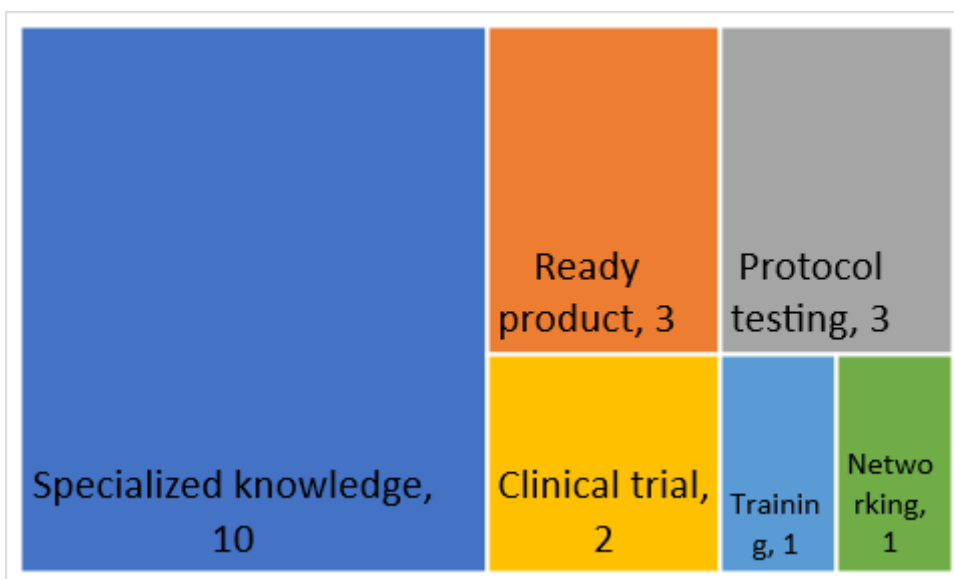


Figure 2 : Primary reasons of an academic collaboration (Source: Respondents' comments)

Qualitative analysis

Table 1: Word frequency table from the interviews (Source: Interviews)

Word	% of text	Occurrence
collaboration	2.77 %	67
academia	1.45 %	35
industry	1.28 %	31
institute	0.62 %	15
university	0.54 %	13
academic	0.45 %	11
research	0.45 %	11
development	0.45 %	11
medical	0.41 %	10
professors	0.33 %	8
collaborations	0.33 %	8
college	0.33 %	8
products	0.33 %	8
product	0.33 %	8
knowledge	0.29 %	7
colleges	0.25 %	6
universities	0.21 %	5
institutes	0.21 %	5
instruments	0.17 %	4
hospitals	0.17 %	4
specialized	0.12 %	3
complexity	0.12 %	3
technology	0.12 %	3

The Word Frequency table (Table 1) through the analysis of the scripts recorded showed that the words “academia, industry, institute, university, college.” were the top words captured during the interviews, and this is natural since these words represent the subject of our interview. The next words were “research, development, medical, products, knowledge, instruments, hospitals, specialized, complexity, and technology”. These are more important giving insight into the objectives of collaborations. The words “Knowledge, Instruments, Hospitals, Specialized, Complexity and Technology” are in line with the objectives of specialized knowledge and ready product/technology objectives.

The same results can also be seen in the word – cloud below (Figure 3). The transcripts were also subjected to the Word Cloud formation programs. The word Cloud captures the same essence effectively where these particular words are represented by proportionate sizes for these keywords. Since this format of the Word Cloud shows a relative proportion of the frequency of words, this style was chosen.



Figure 3: Word Cloud from the scripts (Source: Table 1)

Comments from the interviews

Interview comments relevant to the subject but are critical responses are covered here, to understand the barriers and constraints.

Respondent A - an x-ray machine manufacturer in the line for 30 years

We do not have a collaboration with any college. (Q:Why?) We have been working for 30 years. We have gathered sufficient knowledge in this line. Therefore it is not necessary to have any collaboration. It is a management decision. (The respondent was a senior-most manager, not part of the owner's family.)

Respondent B - a 5 years old company of small size

I mean, actually, we have collaborations but they are not with institutions or academic universities. They are with independent professors. These professors are associated with some good universities and academic institutes. This way of relationship is easier to manage instead of managing a relationship through a college because of institutional bureaucracy.

Respondent C - a wound care products startup

Industry-academia collaboration is important for our line. What we do is, we give our free products for trials to hospitals under collaboration, they do trials and then we collect the data and we publish the data, we include the hospital name as well as the doctor's names. So they feel motivated and they always feel involved, and they start using the final products when introduced to them. It is more like a win-win collaboration because we are a small company, we can't afford big money to be paid.

Respondent D- a fairly large operation theatre accessories manufacturer

My experience of such collaborations is not very positive. Most of the colleges lack infrastructure for our type of products like electrical or electromagnetic products. The ecosystem of these colleges or institutes is not conducive. I really do not feel very comfortable dealing with them here.

Respondent E - a large disposable products manufacturer

I had actually initiated this (industry-academia collaboration) process, but it did not work out, unfortunately. And I understand and appreciate your points that we can always get specialized knowledge or technological know-how, the latest know-how, but this does not work. And right now, we do not have any collaboration. (When probed about his experience) Better not to speak about our past experiences. The past is gone.

Respondent F - A diagnostic products and machine manufacturer

We were working with BARC long ago, and it was a good working arrangement, but now we do not need BARC because there are private players in radiation technology with good service.

Respondent G - a very old diagnostic company

There were lot many dynamics. We are in business, we don't want to enter into their internal politics. Why should we? It is very complicated. Now we have just stopped that as a policy. In India, the problem is the syllabus of universities and colleges is not appropriate. It is more towards the academic side. Instruments, for example, their own instruments are very old. Universities in India are not investing in newer developments. They are laggards. Education should be at the forefront while these people are lagging. So, not worth entering into collaboration.

Respondent H - a textile manufacturer who diverted to collagen sheet manufacturing

You see, IITs in India have the newest or the best instruments. However, after a year or so, these machines or instruments become dormant, and nobody uses them. When they order, probably there is some project in their hand. But then after some time, the project is over or the project gets abandoned and the machine becomes dormant and the machine just lies, and nobody knows, nobody cares or nobody maintains that machine.

Discussion

Little less than one-third of companies involved in serious industry-academia collaboration for new product development is an area of attention for policymakers, especially when new product development is the way to reduce import dependence. Good R&D investments in the pharma sector, a similar area in the healthcare arena,

and its excellent export contribution to India is a situation worth comparing. This lack of collaboration was across the size of the companies, the life of the companies and the types of products. However, there was a correlation between the companies with 5% or more R&D expenditure and academic collaboration. This, along with more frequent words mentioned like “research, development” are indicators that the role of academic collaborations for new product research and development is the main objective of the industry players. Looking for specialized knowledge was the most common reason for seeking a collaboration with an academic institute. This is also in line with this new product development need. As discussed earlier in the article, the complexity of medical devices does prompt a medical device company for such collaborations because a company may not always have specialized knowledge of all the areas which are needed for new product development.

Why no collaboration? A large majority, 35 out of 44 respondents said that there is no need for any such collaboration. There is a strong possibility that most of these respondent companies do not have serious R&D plans. Some comments in the interview (respondent A, for example) also indicate less inclination of these companies towards R&D. This is in line with what KPMG (2022) has also reported for the whole sector. Some unique ingenious models found by these entrepreneurs, like using hospitals for trials as well as future launch platforms, and connecting with individual professors bypassing the bureaucracy of institutes were also captured in the comments mentioned. Two responses mentioned that there is no specialized knowledge available for their types of products or technologies in the colleges and one response mentioned that he does not know whom to approach. It may be worth noting here, that a study conducted by the Entrepreneurship Development Institute of India for the Department of Pharmaceuticals (DoP), “Bridging the academia-industry gap to achieve self-reliance for NIPER institutions in India”, The National Institutes of Pharmaceutical Education and Research (NIPERs) need to establish a more comprehensive ecosystem that includes mentorship, support for incubation, funding methods, and industrial alliances to promote entrepreneurship in the pharmaceutical sector. National Institutes of Pharmaceutical Education and Research (NIPERs) should focus on multidisciplinary research to bridge the gap between academic education and the needs of the country's health industry (PharmaBiz, 2024).

The comments of respondents regarding their complicated and negative past experience of such collaborations is somewhat alarming. If we park aside the reason of “No Need”, the next most significant reason for not entering into a relationship with academic institutes was such experience. Some companies did the efforts but did not get conducive responses in the past and so, now they are averse to such collaborations. Internal politics and bureaucracy of academic institutions were stated clearly by some respondents. In a very well-discussed and highly quoted theoretical model called the Triple Helix model, Etzkowitz and Leydesdorff (1998) have touched upon the barriers of the industry-academia relationship. Abd Razak and White (2015) have elaborated further on the barriers based on this Triple Helix model for innovation, stating that there are three types of barriers - Relationship issues; Perception issues; and Policy issues. The data in the current study suggests that the issues present are the “Relationship” issues. The issues are not “perceived barriers” as they are based on actual experience rather than perception. The problems are not issues of internal “Policies” of the companies also. In other words, “Trust”, *materia prima* for a successful “Relationship” seems to be missing. The Hamamatsu models discussed in the article using volunteer commercial coordinators may be highly effective in this situation (Yuko, 2020). These Commercial Coordinators may facilitate the meetings and work as the coordinators as their name suggests. The study also reveals that there exist successful collaborations in the industry. Therefore, it is right to assume that the collaborative models are workable if nurtured carefully and sensitively.

Conclusions and Recommendations

To answer the first objective, the extent of industry-academia collaboration is 31%, which appears low. For a successful new product development culture for the medical device sector in India, this should go up. The major objectives of such collaborations from the industry side are to gain specialised knowledge and to adopt readily developed products by the universities. The major barrier is under the sub-theme of “Relationship” or trust deficit. It is recommended that there be more trust-building and interactive processes between both sides. These can build a bridge between industry and academia for such collaboration. The policymakers may need to look into collaboration-enhancing models, which will help in more innovative culture and will ultimately help in reducing import dependence of the sector.

Limitations and further scopes of the study

A similar study to understand the views from the academicians’ side may be a very interesting possibility. This part is not covered in the current study and this is a limitation as well as a future opportunity. One more limitation was that this study was restricted to the medical devices field, and similar studies with some other healthcare-related fields like pharma or nutraceuticals may also reveal some interesting possibilities. This also provides a possible scope for future study.

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Gender Representation in Academic Leadership Positions in Universities of Assam, India

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Abstract

This paper sought to study gender status in leadership positions in the universities of Assam, India. The study also assessed the number of male and female university teachers because academic leaders are selected among university teachers. Moreover, the study aimed to determine the causes of gender disparities. This study employed descriptive survey research. The study also used purposive and stratified sampling techniques to sample universities and respondents. Assam state was purposively selected for the study based on the number of available universities. Among the eight states of Northeast India, Assam has many universities compared to the other seven remaining states. With this regard, the study included a total of five universities, three of which were public and two were private. The study included only three academic leadership positions: dean, head of the department, and chairperson/director of the center.

The study found that females were few compared to males in university teaching and academic leadership positions in the universities of Assam, India. Regarding the overall status of males and females in university teaching positions the results were (41.83%) females compared to males (58.17%). Additionally, regarding gender status in academic leadership positions, males were (66.33%) compared to females (33.67%). In position-wise based on three academic positions studied, the results showed that (83.33%) of males and (16.67%) of females held the positions of dean and director/chairperson of the center. The position of head of department was held by (57.69%) males and (42.31%) females. Conversely, the study found that family and work responsibilities, male-dominated structures, and negative perceptions about females are the causes of gender disparity in academic leadership positions in the universities of Assam, India. The study recommends university management employ different strategies for gender parity in academic leadership positions. The more females are underrepresented in leadership positions, the more they lack representatives in decision-making

Key Words: Gender Representation, Gender Disparities, Academic Leadership, Universities

Introduction

The presence of gender inequalities or differences in any area between males and females results in a gender disparity/gap that means separating males and females regarding opportunities and access to positions (Rincon et al., 2017). According to Elbers and Grigore (2019), Rights, duties, and opportunities should not depend on whether a person was born a male or female; both should be treated equally in rights, opportunities, and responsibilities regardless of gender. The gender gap exists in all countries worldwide. Gender disparities have decreased in high- and middle-income countries, but they are still significant in low-income countries, females are still disadvantaged in several sectors, including education and employment (Macis, 2017).

According to Jain (2020), in India, males control economics, politics, religion, and social institutions. Females are highly underrepresented in leadership, as in many other occupations; males dominate senior leadership positions in all phases of education, except in nursery and infant schools (Bush, 2003). The study by Nyoni et al. (2017) demonstrated that females in universities are negatively perceived in leadership issues and masculine concepts dominate the leadership system.

Academic leadership is crucial in developing universities and research institutes; it includes various educational roles, positions, and titles (Yue et al., 2021). According to Saroyan et al. (2011), academic leadership occurs in an academic setting, communicates vision, direction, inspiration, and support, and guides the team toward achieving a common purpose. Academic leadership in universities includes positions, roles, and titles of Heads of Academic Departments, Deans of Faculty/Schools, Directors/Chairpersons of Centres, Academic Registrar, Deputy Vice-Chancellor Academic, and Vice-Chancellor.

This paper seeks to analyze and compare the status of gender representation in academic leadership in universities of Assam, India specifically in the positions of deans, heads of departments, and directors/chairpersons of centers. Based on the fact that Academic leaders are selected or appointed among

university teachers. Hence, the study assessed the number of male and female university teachers. Furthermore, the study determined the causes of gender disparities in academic leadership positions.

Literature Review

The status of gender in academic leadership in universities

Several studies investigated gender representation in university academic leadership and found that females are underrepresented compared to males. Gender disparity in academic leadership positions is a worldwide problem.

Nguyen, et al. (2022) conducted a study in the United States; out of 157 deans, the study found that males were 124, equal to 79.9%, while females were 33, equal to 21.0%. Azizi et al. (2022) conducted a study in North America and found that males were 63.7% while females were 36.3% in the position of Vice-Chancellor: 61.5% were males and 38.5% were females in the position of dean. Sethi et al. (2022) conducted a study to address gender disparity in the United States. The study found that in the position of directors, males were 76% while females were 24%; in the position of chairman, males were 86%, while females were 14%.

Çobanoğlu (2018) conducted a study in Turkey in the position of rectors; males were 92% while females were 8%; in the position of Vice-Chancellor, females were 17.39%, and 18.33% in the position of dean. Qamar et al. (2019) conducted a study in Canadian Universities and found that males were 70.45% while 29.55% were females. Morais, et al. (2022) studied leadership and gender distribution in Portuguese higher education institutions and found that male deans were 69.5% while females were 30.5%. Aiston and Yang (2017) conducted a study in Hong Kong and found that males were 81.0% while females were 18.7% and missing 0.2%.

Haidar (2018) conducted a study in Lebanon; out of 65 deans, there were only 15 (23%) females while the rest were males. Alsubaie and Jones (2017) conducted a study in Saudi Arabia, The study found that females were underrepresented in all leadership positions out of 34 directors, males were 33 while one (1) director represented females. Out of 140 Vice Presidents, males were 128 while females were 12; out of 391 deans of faculty males were 330 while females were 61; and out of 770 deputy deans of faculty, males were 542 and females were 228.

Rudhumbu (2016) conducted a study in South Africa and found males were 65.35% and females were 34.7% (head of departments), 75% for males, and 25% for females (deans). Eboiyehi et al. (2016) conducted a study in Nigeria and found that males were 70.8% while females were 29.2%. Moreover, the study demonstrated that most deans and vice deans were males, and in the position of vice-rector, only one female was a vice-rector of academic affairs. Adu-Oppong et al. (2017) conducted a study in Ghana and found that female heads of department were 18%. The deans of the faculty were all males and only one female. Omotos (2021) conducted a study on Nigeria's deans of faculties; in 2016, male dean faculties were 88%, while females were 12%. In 2017, the percentages remained the same: 88% for males and 12% for females. In the position of heads of department in 2016, males were 84% while females were 16%; in 2017, males were 53% while females were 47%.

Banker and Banker (2017) in India found that out of 810 higher education institutes or universities, only 6.67% of institutions were represented by females, while male representation was 89.52% and 3.83% unknown. Basantia and Devi (2022) conducted a study in Northeast India and found in the position of Vice Chancellor; males were 100%; in the head of the department, females were 9.85%, and males were 90.14%. Banker (2023), found that out of 1151 higher education institutions in India, 9.55% are led by females and 89.57% by males, and 0.86% of data on leadership is unavailable. Moreover, Kumari and Misra (2020) found that in Indian universities female representation has been seen to be 11.79% compared to males who were 83.32% in the position of Vice-Chancellor, dean, or director.

Nyoni and He (2019) conducted a study in Tanzania at the University of Dodoma and found that the representation of females was 8.2% and 91.8% for males; at Jordan University, the study found males were represented by 93.3% while females were represented by 6.97%. Mushi et al. (2021) conducted a study in Tanzania; the study found that, in top management, males represented 81% while females represented 19%; in the level of directors, males were 81% while females were 19%, in the level of heads of departments males were 68% while females were 32%.

Causes of Gender Disparities in Academic Leadership Positions in Universities

The study by Chliwniak (1997) found stereotypes, and the blocking of the career paths of females due to male-dominated structures, organizational norms, and systems are the causes behind unequal representation in university leadership. Oakley (2000) found gender-based stereotypes and the closed circle of the boy network. Moreover, Onsongo (2004) found a lack of confidence, discriminatory recruitment, appointment and promotion procedures, and discrimination against female child education as causes of unequal representation in academic leadership in universities. Also, the study by Shakeshaft et al. (2007) mentioned that family and home responsibilities affect the career patterns of females more than males. Moreover, it demonstrated that stereotypes and discrimination impede female leadership.

Özkanlı and White (2009) found that a lack of support, mentoring, and recruitment and selection processes causes the underrepresentation of females in leadership positions. Batool et al. (2013) found domestic responsibilities, females were limited from engaging in research activities, leading to a lack of publication and underrepresentation in leadership. Segkulu and Gyimah (2016) found that low education qualifications, traditional beliefs, and cultural practices limited females from occupying leadership in educational institutions. The study by Addama (2017) found the dominance of males in tertiary institutions causes unequal representation in academic leadership.

Haidar (2018) found stereotypes and discrimination as causes of unequal representation. Çobanoğlu (2018) found that social-cultural factors, academic working culture, and personal factors hinder females' progress to leadership compared to males. The study conducted by Dawa and Ugyen (2022) found gender biases, no incentives for females to take up leadership positions from authorities, and social-cultural factors like family responsibilities and lack of gender equality in assigned leadership positions cause unequal representation.

According to the study conducted by Nyoni and He (2019) society and organizations have determined that males are the only ones who make good leaders. In addition, Nyoni et al. (2017) demonstrated that the masculine concept dominates the leadership system. Furthermore, the study showed that females were discriminated against in appointments and promotions in universities. In contrast, males with equivalent qualifications were given better positions, resulting in unequal representation in university leadership positions. The study by Joseph and Joseph (2022) found organizational culture, discrimination in recruitment, and unequal power relations.

Objectives

- To find out the number of male and female university teachers in universities of Assam, India.
- To find out the status of gender representation in academic leadership positions in universities of Assam, India.
- To find out the causes of gender disparities in academic leadership positions in universities of Assam, India.

Research Methodology

The study used a descriptive research method. Purposive and stratified sampling procedures were used. Purposive sampling was used to select universities and the respondents from the Registrar's office. Furthermore, the study used stratified sampling to select university teachers.

Participants

The study included five universities from Assam India (one central, two states and two private universities) with a total of 175 university teachers and five (5) respondents from the registrar's office.

Data collection tools

To answer the first two objectives; a data schedule was used, which was filled by the offices of Registrars. Regarding the comparison of the causes of unequal representation in academic leadership; questionnaires were used, which were administered to university teachers.

Data analysis

The Statistical Package for Social Science (SPSS) program was used to analyze data collected through a questionnaire. Tables, simple percentages, and graphical representations were used in presenting data.

Analysis and Findings

The Number of University Teachers in Universities of Assam, India

To answer objective one (1), data were collected through a data schedule that the Registrar's office filled. The number of male and female university teachers in the universities of Assam, India, is presented in Table 1, UNI means university;

Table 1: The Number of Males and Females University Teachers in Universities of Assam, India

Name of university	Number of teachers	Males		Females	
		Number	Percentage	Number	Percentage
UNI 1	200	134	67%	66	33.00%
UNI 2	220	134	60.91%	86	39.09%
UNI 3	344	144	41.86%	200	58.14%
UNI 4	44	18	40.91%	26	59.09%
UNI 5	275	200	72.73%	75	27.27%

Table 1 shows the number of teachers in universities in Assam, India. At UNI 1 67.00% of teachers were males, and 33.00% were females (as per data collected in September 2023). At UNI 2 60.91% were males, while 39.09% were females (as per data collected in September 2023). At UNI 3 41.86% were males, and 58.14% were females (data collected in October 2023). At UNI 4 40.91% were males and 59.09% were females (as per data collected in November 2023). And UNI 5, 72.73% were males while 27.27% were females (as per data collected in February 2024).

Table 2 below shows the total number of male and female teachers in the universities of Assam, India.

Table 2: Total Number of Male and Female University Teachers in the Universities of Assam, India

Number of Teachers	Males		Females	
	Number	Percentage	Number	Percentage
1083	630	58.17%	453	41.83%

Table 2 shows the total number of 1083 university teachers in Assam, India; 630 (58.17%) were males and 453 (41.83%) were females (as per data collected in academic year 2023/2024).

The Status of Gender Representations in Academic Leadership Positions in Universities of Assam, India.

Data were collected through a data schedule that was filled by the Registrar's office. The representation of males and females in academic leadership positions in universities of Assam, India is presented as shown in Table 3:

Table 3 : The Number of Male and Female Academic Leaders in Academic Leadership Positions in Assam, India (in university wise)

Name of university	Academic leadership position	Total Number	Males		Females	
			Number	Percentage	Number	Percentage
UNI 1	Deans	09	06	66.67%	03	33.33%
	Heads of Department	17	11	64.71%	06	35.29%
	Directors/Chairpersons of Centers	17	14	82.35%	03	17.65%
UNI 2	Deans	05	05	100%	00	0%
	Heads of Department	25	16	64%	09	36%
	Directors/Chairpersons of	03	01	33.33%	02	66.67%

UNI 3	Centers					
	Deans	14	12	85.71%	02	14.29%
UNI 4	Heads of Department	42	19	45.24%	23	54.76%
	Head of Departments	15	6	40%	9	60%
UNI 5	Deans	8	7	87.5%	1	12.5%
	Heads of Department	31	23	74.19%	8	25.81%
	Directors of Centres	10	10	100%	0	0%

Table 3 summarizes the number of male and female academic leaders of five universities in Assam, India, based on academic leadership positions (as per data collected in academic year 2023/2024).

Table 4: The Representation of Males and Females in Academic Leadership Positions in Universities of Assam, India (in Leadership Position Wise).

Leadership Position	Total Number of Academic Leaders	Males		Females	
		Number	Percentage	Number	Percentage
Deans	36	30	83.33%	6	
Directors/Chairpersons of Centres	30	25	83.33%	5	
HoD's	130	75	57.69%	55	42.31%

Table 4 shows the representation of males and females in academic leadership positions as follows: in the position of dean, males were 83.33%, and females were 16.67%; in the position of directors, males were 83.33%, and females were 16.67%; and in the position of head of department males were 57.69% and females were 42.31% (as per data collected in the academic year 2023/2024).

The overall representation of males and females in academic leadership positions in universities of Assam, India is presented in Table 5:

Table 5: Total number of Male and Female Academic Leaders in Universities of Assam, India

Number of Academic leaders	Males		Females	
	Number	Percentage	Number	Percentage
196	130	66.33%	66	33.67%

Table 5 shows that in universities found in Assam, India, the overall representation of in academic leadership positions; males were 66.33%, while females were 33.67% (as per data collected in the academic year 2023/2024).

The causes of gender disparities in academic leadership positions in universities of Assam, India

The questionnaires and interviews were used to answer this objective. The researcher administered 175 Questionnaires to university teachers 175 university teachers from Assam, India.

Through the questionnaire causes of gender disparity (unequal representation) in academic leadership in universities were grouped into three categories; individual, organizational, and social-cultural. The Statistical Package for Social Science software program was used to analyze data through multiple responses analysis.

Individual Causes of Gender Disparities in Academic Leadership Positions in Universities.

Table 6: Individual Causes of Gender Disparity in Academic Leadership Positions in Universities of Assam, India

Causes of gender disparity in academic leadership Positions		Respondents	
		N	Percent of Cases
I	Qualifications	14	8.0%
ii	Low self-confidence	20	11.4%
iii	Family and work responsibilities	142	81.1%
iv	Lack of role models in leadership	35	20.0%
V	Lack of interest in taking leadership positions	34	19.4%
	Others(please specify) (glass ceiling, mansplaining fear of conspiracy, back pulling and readiness)	05	2.9%

Table 6 shows Family and work responsibilities (81.1%) which was selected by 142 out of 175 university teachers as an individual cause of gender disparity in academic leadership positions in universities of Assam, India.

Institutional Causes of Gender Disparities in Academic Leadership Positions in Universities

Table 7: Institutional Causes of Gender Disparity in Academic Leadership Positions in Universities of Assam, India

Causes of gender disparity in academic leadership positions		Respondents	
		N	Percent
i	The presence of few female university teachers compared to males	51	29.1%
ii	Absence of policies ensuring equal participation of males and females in academic leadership positions	61	34.9%
iii	Discriminating against females over males	56	32.0%
iv	lack of gender consideration when appointing academic leaders	58	33.1%
V	Male-dominated structures	76	43.4%
vi	Others(please specify) (seniority, negative work environment, awareness, females are considered as non-fit)	6	3.4%

Table 7 shows that 76 university teachers out of 175 equal to 43.4% selected male-dominated structures as an institutional cause of gender disparity in academic leadership in universities in Assam, India.

Social- Cultural Causes of Gender Disparities in Academic Leadership Positions in Universities

Table 8: Social-Cultural Causes of Gender Disparity in Academic Leadership Positions in Universities of Assam, India

Causes of gender disparity in academic leadership positions		espondents	
		ercent	of Cases
	egative perceptions about female	2	6.9%
	iving in male dominating society	7	8.3%
i	he culture of undermining female leadership capabilities	3	4.3%
	ultural, religious beliefs and values	7	1.1%
	imited support from society	3	5.7%
i	thers (please specify) (gender prejudice, gender stigmatization, patriarchal mindset and cultural aspects)	1	3%

Table 8 shows that 82 university teachers out of 175 equal to 46.9% selected negative perceptions about females as a social-cultural cause of unequal representation in academic leadership.

Discussion

Findings regarding the number of male and female university teachers, the study found that the percentage of male university teachers was 58.18% while that of females was 41.83%. The study's findings relate to the study conducted by Nidhinalwaya (2022), the study found that in Indian universities, female faculty members were 39% while male faculty members were 61%. Ghatge and Parasar (2022) found a ratio of 59 females per 100 university teachers. The findings also relate to studies conducted by Adu-Oppong, et al. (2012) and Lekve and Gunnes (2022); the studies found few female teachers compared to males in universities.

Regarding the status of gender representation in academic leadership positions; the study found that; 66.33% of academic leaders were males while 33.67% were females. In leadership positions-wise, males were 83.33% and females were 16.67% (dean position). 83.33% were males and 16.67% were females in the position of directors/ chairperson of center, males were 57.69% and females were 42.31% in the position of head of the department. The finding implies that females are underrepresented in all leadership positions. The findings relate to the studies conducted by Omotos (2021); the study found the representation of males in the position of deans was 88% while for females was 12%; in the position of head of department, males were 53% while females were 47%. Also, relates to the study conducted by Cho, et al. (2017) that found male deans were 88% while females were 12%. Nguyen et al. (2022) found that male deans were 79.9% while females were 21.0%. Moreover, the study's findings relate to the following studies: Basantia et al. (2021), Mayya, et al. (2021), Gandhi and Sen (2020), Dandan and Marques (2017), Eboiyehi, et al. (2016), and Batool, et al. (2013), the studies found that males are more represented compared to females in academic leadership in universities.

Regarding causes of gender disparities in academic leadership positions; the study found that family and work responsibility, male-dominated structures and negative perceptions about females contribute to the gender disparity (unequal representation) in academic leadership positions in universities in Assam, India.

Family and work responsibility personal factors contributing to the gender disparity in university academic leadership positions. The findings relate to Mushi, et al. (2021) found that family commitments contribute to gender disparities in leadership positions. Dawa and Ugyen (2022) found that family responsibilities cause a gender gap in leadership. Furthermore, Alemayehu (2021) found that females are more responsible for home and family concerns than males. Bernal et al. (2017) found that parenthood was a barrier to female career pathways, not males. Batool, et al. (2013) also found that due to domestic responsibilities, females were limited to engaging in research activities, leading to a lack of publication and underrepresentation in leadership. Moreover, Shakeshaft et al. (2007) found family and home responsibilities affect females than males in their careers.

The male-dominated structure; is the institutional factor contributing to the gender disparity in university academic leadership positions. The findings relate to Kohtamaki, et al. (2023), whose study found that male-dominated structures contribute to the gender gap across Bangladesh, China, and Finland. Nidhinalwaya (2022) demonstrated that the dominance of males in decision-making affects the growth of females. Moreover, Dandan and Margues (2017) found that male-dominated is a factor for unequal representation; the study explained that the world of males and females seemed different at Jordanian University regarding management and leadership positions.

Negative perceptions about females: based on the findings, the negative perception of females is a social-cultural factor that causes gender disparity in university academic leadership. The findings relate to the studies that were conducted by Khamis (2023), Mwakitalu, et al. (2018), and Segkulu and Gyimah (2016), their studies found negative perception about females is a factor causing the presence of few females compared to males in academic leadership in universities.

Conclusion

The study found that the overall representation of males and females in academic leadership positions in universities of Assam, India, males were 66.33% while females were 33.67%. In dean and director positions, the gap was too extensive, males were 83.33% while females were 16.67%; in the position of director, males were 83.33% while females were 16.67%. However, the status of males and females in the position of the head of the department in Assam, India, was promising, whereby males were 57.69% while females were 42.31%; soon, the gap might close. The study found that family and work responsibilities, male-dominated structures, and negative perceptions about females are the causes of gender disparities in academic leadership positions in universities of Assam, India

Recommendation

The study recommends universities employ different strategies for gender parity in academic leadership positions. The more females are underrepresented in leadership positions the more they lack representatives in decision-making.

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Assessing the Ramifications of Unpaid Work on Emotional Distress and Physical Health Deterioration among women in North Chennai

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Abstract

Despite greater employment for women, a substantial section of the population continues to do a disproportionate amount of unpaid housework, forcing them to juggle multiple obligations at once. Women struggle to reconcile work and family responsibilities, and this dual burden, combined with the demands of paid job, produces severe emotional discomfort and physical health degradation. This imbalance affects not just women's well-being, but also their productivity and quality of life. The disparate allocation of family responsibilities reinforces the gender disparity by putting more pressure on women to satisfy cultural standards. To build healthier and more balanced lifestyles for women, policy makers must take certain measures to alleviate their distress. The study took both qualitative and quantitative data to attain the objective. Initially, a focus group was organized involving 15 women from North Chennai engaged in the unorganized sector to explore their experiences with unpaid house work and paid employment. Following this, a survey was administered to 250 women from North Chennai engaged in the unorganized sector using a structured questionnaire developed from the discussion, employing a convenience sampling technique. The quantitative data were analyzed to identify link between unpaid work(UPW), emotional distress(ED)and physical health deterioration(P), while the qualitative insights provided a profound understanding of the living conditions of these women. The quantitative analysis was carried out with statistical tools such as SPSS and Smart PLS. The Mann-Whitney and Kruskal-Wallis tests were used to evaluate group differences, offering a robust and non-parametric analysis. Furthermore, Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to look into the linkages between unpaid work, mental discomfort, and physical health deterioration. This method disclosed facts about how unpaid work adds to psychological difficulties and affects overall health. The outcome explained that female who engage in both unpaid housework and paid employment faces momentous cognitive health challenges and decreased physical wellbeing.

Keywords: Unpaid work, Emotional distress, Physical health deterioration, Women, Unorganized sector.

Introduction

Unpaid work of women has a substantial blow on daily living and health, particularly mental health, and is primarily carried out by women globally. A perceived imbalance contributes to family conflicts, which may impede job performance and affect wellbeing (Fettró and Nomaguchi, 2018). The work burden is high among female who are self-employed, young children & elderly people care taker, and other employed individuals. A lot of women have to balance both paid and unpaid labor, which can cause stress, role overload, and time poverty (Ervin et al., 2023, McGinnity and Russell (2007). Employment can provide women with revenue, social engagement, and self-identity benefits as well as challenges (Lu et al., 2023). Women around the world devote an average of four hours and twenty-five minutes a day to this essential but underappreciated labor, while men only devote one hour and twenty-three minutes. This gender disparity in unpaid care work is a notable gauge of inequality. Unpaid care work's vital role in family well-being and economic steadiness is highlighted by the International Labour Organization's (ILO) classification of unpaid care work into three categories: household service, care giving, and community services. But frequently, this unpaid work goes unrewarding, which perpetuates gender inequality and affects general well being of women. Despite being a crucial but little-studied topic, women are more severely impacted by unpaid labor, particularly that impacts mental health and general well being. The community of North Chennai chiefly composed of working-class families, facing significant socioeconomic challenges, including lower incomes. Many residents are employed in low-wage jobs within the manufacturing, service, and informal sectors, struggling to meet basic needs. This economic backdrop exacerbates the prey on women, who are often accountable for a disproportionate amount of unpaid labor, including household chores and care giving, alongside their formal employment.

Research gap

Despite increasing evidence linking unpaid work to emotional distress and physical health deterioration, considerable research gaps exist, particularly concerning causal relationships. Most existing studies are based on

cross-sectional designs, which fail to ascertain causal links between unpaid work, emotional distress and physical health deterioration. Numerous research studies on unpaid work focuses on formal sectors but few research studies examine the effect of unpaid work on emotional distress and physical health deterioration. There is also an understanding vacuum on the unique difficulties faced by women in the unorganized sector in North Chennai. This study attempts to close this gap by investigating the causal relationship between unpaid work and both emotional distress and physical health deterioration using a 'mixed-methods approach' taking into account 'gendered experiences' and 'socio-demographic factors' impacting women working in the unorganized sector in North Chennai.

Research questions:

- What challenges and adversities do women experience as a result of unpaid labor?
- Do differences in unpaid labor depend on the occupation of women?
- Does deteriorating physical health and mental anguish relate to women's occupation?
- What variations exist in unpaid labor among women according to their marital status?
- Does the pecuniary assistance of spouse impacts unpaid work of women?
- Are women's physical health deterioration and emotional distress influenced by the financial support of their marriages?
- What impact does family size have on the disparities in women's declining physical health?
- Does educational qualification have a major impact on emotional anguish levels?
- How does unpaid work create a burden on women's emotional distress?
- What is the liaison between women's voluntary effort and their physical health?

Objectives of the study:

General objectives:

- To comprehend the challenges along with hardships women experience as a consequence of unpaid labor.
- To examine the socio-demographic factors that influence unpaid work, emotional distress, and physical health deterioration in women, such as occupation type, marital status, spousal financial support, family size and the level of education.
- To investigate how unpaid labor of women affects physical and mental health.

Specific objectives

- To observe the differences in the unpaid work, emotional distress and physical health deterioration on the basis of the type of occupation of women.
- To examine the differences in the unpaid work on the basis of women's marital status.
- To scrutinize whether the unpaid work, emotional distress and physical health deterioration of women differs when financial support has been provided by the spouse.
- To study the differences in the physical health deterioration on the basis of family size.
- To learn the relationship between educational attainment and emotional distress levels.
- To examine the affiliation between women's unpaid work and emotional distress
- To probe the connection linking women's unpaid work and physical health deterioration

Literature Review

Unpaid work for women often branches out from societal and patriarchal norms. It limits their entry in the labor market and forces them to depend on others. This situation constrains women's choice concerning paid work, particularly in low-paying and insecure jobs. Unpaid work among women is a central issue but it is often not recognized element of the economy. Women spend longer hours on both paid and unpaid labor compared to men and there is a need of data that encompasses their contribution. Women also decide on how they allocate their time when they make up their mind to participate in the labor market. This includes weighing the trade-offs between leisure and work, as well as accounting for home-based production and care giving responsibilities (Becker, 1965). The debates of capitalism's crises tend to concentrate on monetary and ecological problems, ignoring social reproduction, which encompasses unpaid care labor. Unpaid care work is externalized onto families by capitalism, which increases poverty by disproportionately hurting women in underdeveloped nations who frequently relocate to sell their labor (Tasnim, 2020). The dual role of women as working both in the labor market and at home is instrumental in enhancing a country's productivity. The tendency for women to be more involved in household chores is evident even when both genders work and earn comparable incomes (Chauhan, 2021). The volume of unpaid work carried out by women at home often restricts their ability to pursue career advancement opportunities, thereby affecting their current and future earnings. They receive fewer chances for promotions, salary increases, and skill advancement, leading to a decrease in potential income. This also impacts their retirement, resulting in reduced retirement savings and benefits. Ultimately, women face financial insecurity in older age due to unpaid labor (Iusardi, 2007). Many female cares for family members with disease,

experience stress which may concern their physical health as well (Vitaliano et al., 2003). Despite providing a certain amount of independence and fulfillment, domestic work lacks social status and institutional acknowledgment, which may make it more likely to cause sadness, particularly in environments with minimal resources. Especially for moms and wives, juggling numerous responsibilities, like childcare and labor, causes role conflict, elevated stress, and anxiety (Owoo and Lambon-Quayefio (2021). According to Butterworth et al. (2011), emotional wellness is greatly impacted by the psychosocial quality of one's job. Even while having a work generally improves mental health, people in low-quality jobs had worse mental health than those without jobs. Piovani and Aydiner-Avsar (2021) discovered that emotional distress is consistently correlated with total work time, which includes both paid and unpaid labor, for women, but not for men. According to their data, the amount of time spent on voluntary labor rather than paid job has a greater influence on women's cognitive health. This implies that women's emotional health is affected greatly by the accumulated load of unpaid labor. According to the study, assessing both productive (paid) and reproductive (unpaid) labor is crucial for creating public policies that support social justice and gender parity. Women in India spend roughly twice as much time on amateur care work and three times as long on domestic chores when judge against to men, unfortunately this saddle of responsibility is expected to increase due to a growing elderly population (Sinha et al., 2024). Women who undergo household tasks and childcare get highly stressful and has increased cortisol levels in their bodies (Sjörs et al., 2014). Sex-based cultural and social customs position female as caregivers and bringers, which may be linked with worse mental health outcomes for them. Time allocation is distinctly gendered as women often more satisfied working part-time due to their dual role in both paid employment and unpaid domestic tasks. This double shift directs to differing life satisfaction levels between partners. Men's time use brings into line with usual gender roles, while women tend to assume more egalitarian attitudes (De Rock & Périlleux, 2023). Several studies show a correlation between mind wellbeing and low income status, signifying that individuals with lower social and economical status experience a higher prevalence of mental health issues compared to those with higher socioeconomic status (Muntaner et al., 2004). High demands and low control in domestic roles considerably impair women's mental health. This imbalance, rooted in conventional gender expectations, places a grave burden on women, leading to augmented stress and psychological distress. To improve mental well-being, it is indispensable to promote a more equitable distribution of domestic responsibilities (Maeda et al., 2019).

Methods

This study employed a mixed methods approach. One focus group was organized under the study as a qualitative data collection method, which is effective for understanding the social norms of a community or subgroup. The focus group was held with fifteen women, using open-ended questions to gather insights. Participants included women engaged in domestic work, street hawking, food preparation and vending, auto driving, and construction work in North Chennai, exploring their knowledge and perceptions of unpaid labor. Through a qualitative interpretive methodology, the study aimed to understand the significance these women attribute to their unpaid work and the societal expectations placed upon them.

Participants

The study comprised of women with diverse occupations, including domestic work, street hawking, food preparation and vending, auto driving, and construction work, as well as varying levels of education and age. All individuals who voiced interest and were available to take part in the group were regarded. The names of all participants are pseudonyms to maintain confidentiality.

The Research Process

To comprehend the magnitude of challenges undergo by women as a corollary of voluntary labor, A focus group was conducted initially with women in North Chennai. Following the session, a structured questionnaire was prepared in both English and Tamil. Interviews with 250 women workers were conducted, they were from various parts of North Chennai. Some participants were met in person, while others were contacted by phone. On the basis of the women workers' responses, a quantitative analysis was performed to investigate the negative consequence of unpaid labor on their mental health and general well-being. Convenience sampling technique was taken for the study to gather responses for this study. After completion of all interviews, SPSS and Smart PLS software were harnessed as a tool to explore the underlying dynamics of amateur work of women.

Research Model

The proposed conceptual model investigates the causal relationship between “Physical health deterioration”, “Emotional distress” as dependent factors and “Unpaid Work” as independent variable. According to the proposed model of Unpaid Work (UPW), Emotional Distress(ED) and Physical Health Deterioration (P), more unpaid work of women could result in physical strain, tiredness, and poor sleep, which could impair immune systems. Regarding mental health, the strain of working for no pay can result in increased anxiety, stress,

depression and burnout, mostly because of the extreme workload and insufficient time to care for them. The model emphasizes that women may suffer from poor physical and mental health due to unpaid work. The conceptual structure was built on a self-created questionnaire that measured physical health deterioration (P), emotional distress (ED), and unpaid work (UPW). To guarantee content validity, the questionnaire's customized items for each construct were created after a thorough literature review and expert input. Five variables (U1 to U5) were used to measure unpaid work (UPW) in order to determine the nature and extent of such activities. Four variables (M1 to M4) that represent different facets of psychological strain and mental wellness problems were used to measure emotional distress (ED). Three indicators (P1 to P3) that focused on negative physical health outcomes associated with unpaid labor used as a representation of physical health degradation (P). Prior to data collection, the questionnaire was pilot tested to improve clarity and reliability. This allowed for the testing of hypothesized links in the model and the validation of constructs. Certain items measuring the constructs were removed because their factor loadings were below 0.7.

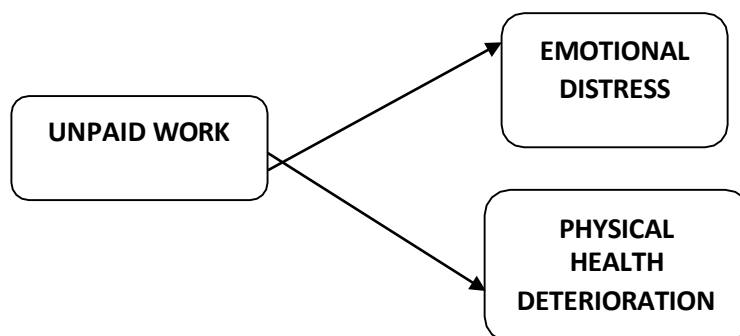


Figure 1: Proposed Model of Unpaid Work (UPW), Emotional Distress(ED) and Physical Health Deterioration (P)

- H1a: Spousal financial support has an effect on UPW, ED and P
- H2a: The burden of UPW, ED and P differs based on the category of employment
- H3a: Differences exist in UPW based on marital status.
- H4a: Emotional distress differs on the basis of family size
- H5a: Emotional distress differs on the basis of the level of educational qualification
- H6a: Unpaid work creates a burden on women's emotional distress
- H7a: Unpaid work affects women's physical health

DATA ANALYSIS

The findings from the qualitative analysis on the impact of unrewarded work on women's lives in North Chennai are as follows:

In exploring the realities of unpaid labor among women in North Chennai, the following narratives reveal the deep struggles and resilience they embody in their everyday lives. Each woman's story demonstrates the intersection of socio-economic pressures, familial expectations, and the persistent demands of their respective roles. Certain painful stories of the women respondents group are highlighted below.

Gowri's (58 years old, domestic worker) highlights the harsh reality faced by her in domestic labor, where both physical endurance and resilience are time and again taken for granted

"One day, I became ill with a painful swelling in my thumb. I knew that if I took a day off, my wages for that day would likely be cut. Despite my condition, I couldn't take a break from my household chores. I also support my married daughter, who works in domestic services as well. So, I completed my household tasks, including sweeping and cooking. Bearing the pain, I then went to work, washing dishes at the houses where I'm employed. Unfortunately, the wound on my thumb worsened, and I eventually had to be hospitalized. During my week of recovery, three of the households I worked for dismissed me because of my absence. Losing those jobs caused me significant financial hardship, and I struggled greatly afterward to make ends meet".

Meenatchi (36 years old, domestic worker) illustrates the struggles she faces in her daily life. Her narrative mirrors the harsh realities of managing multiple responsibilities while enduring physical and emotional abuse.

"Every day, I work in ten houses doing domestic services. When I come home, my irresponsible husband either beats me or abuses me because I cook late at night. He also works as a laborer and expects dinner by 8 PM. I can't afford to buy food from outside, so I have to cook myself. My work at home is challenging because I have to take care of my two children, who are 5 and 8 years old. My mother-in-law, who has high blood pressure, never takes responsibility. I have to work constantly and only get to rest when I visit my mother's house, but that is rare."

Devi (29 years old, an auto driver) provides a glimpse into her challenging daily routine that balances work and family responsibilities and how her family fails to recognize her contribution.

"I take school trips for kids. Every day, I have to wake up early, around 3 AM, to do household chores and cooking at home. After that, I drop my own children along with other kids to school. I earn very little from this work. I take two college girls to their college every day at 10 AM. Then, I pick up the school children and drop them off at their homes. In the evening, I have to help my children with their studies and do the cooking. I don't rest until 11 PM, and I only sleep for four hours. Only on Sundays I get some extra sleep, and even then, my mother-in-law gives me a stern look. I sometimes hate my life because my family fails to appreciate my hardwork and points out my mistakes".

Radha (35 years, a food vendor) offers an emotional insight into her challenging life as a single breadwinner.

"I've started to hate my kitchen because I'm constantly cooking. My husband is an alcoholic and never contributes any money. I'm responsible for paying the school fees of our two children. I started this small business only to support my kids. I can't take a single day off. Standing on the road selling fritters every evening leaves me frustrated and exhausted. My husband, who's often suspicious of me because I work on the street, beats me when he's fully drunk. I hide my sadness from my children. I fail to take care of myself for fear that my husband may misunderstand me. I have dark patches under my eyes, and I haven't gone for any treatment."

Lakshmi (30 years old, a dedicated construction worker) embodies resilience in the face of persistent demands, yet the weight of her responsibilities leaves her in a constant state of sleep deprivation, as she struggles to take rest amidst her exhausting routine.

"I endure a relentless routine every day as a construction worker. I wake up early to prepare food and manage household chores before heading out to the construction site. My job is physically grueling; I lift heavy loads, mix cement, and labor for long hours under the harsh sun. By the evening, my body aches, and my hands are rough and sore, yet my earnings are modest, barely enough to cover my family's basic needs. At home, my responsibilities continue with little support from my husband. Sometimes he refuses to help and blames me for any shortcomings. It feels overwhelming at times, and I wish I received more recognition for the hard work I put in both at the site and at home. I also have trouble falling asleep because my thoughts are focused on unpaid activities and the constant worry of how to manage everything."

Desamma (56 years, a fish vendor) shares a heart-wrenching account of her struggles as a caregiver and a fish vendor, elucidating the challenges of loss and responsibility.

"I lost my son in an accident, and my daughter's life is troubled because her husband is an alcoholic. I am raising her children, and my husband is also a sick patient. My elder daughter sells fish as well. Both my daughter and I walk many streets to sell fish. I have to go to the Kasimedu fish market early in the morning. We wake up at 2:30 AM to cook for the kids. My daughter takes them to school. Every day, we sell fish until 1 PM and then return home to continue with household chores after a lunch break. In the evening, I go back to the fish market to sell fish and usually reach home around 8 PM or 9 PM. One day, my daughter developed a high fever. I was unable to take her to the hospital due to my work commitments. She was on the brink of death but somehow managed herself to get recovered. Our life is a troubled life and we always do dual work, which leaves us lacking physical energy. I just live for my daughter and grandsons".

From the one group focus session, the following points were taken for formulating the questionnaire.

- Most of the unpaid domestic work is usually done by women.
- The contributions made by the women respondents are often not recognized or given credit.
- Personal interests are frequently subordinated to unpaid labor.
- The women respondents become frustrated when their work and related contributions are not acknowledged.
- Emotional weariness and rage can upshot from unappreciated work.
- Low self-esteem, stress, and depressive disorders are widespread problems.
- They are unable to find time for self-care because of their responsibilities.
- Social relationships may decrease as a consequence of unpaid labor obligations.

The quantitative analysis of unpaid labor impact is presented in the following sections. The age of the women respondents indicates that 2 percent were less than 20 years old, 22 percent fall within the age group of 21-30 years, 31 percent are in the 31-40 years age group, 30 percent fall into the 41-50 years category, and the remaining 15 percent are above 50 years. Regarding marital status, 45 percent of the respondents are single, while 55 percent are married. The educational levels of the female respondents show that 34 percent do not have formal education, 35 percent completed primary education, 12 percent completed secondary education, 13

percent completed higher secondary education, and the remaining 7percent fall into other categories. With regard to household size, 35 percent of the female respondents have fewer than 5 members, while 65percent report having more than 5 members. Regarding the type of work, 5percent of the female respondents work as auto drivers, 15percent is employed as construction workers, 20 percent engage in food preparation and vending, 25 percent are Domestic workers, and 35percent are street hawkers. The income distribution reveals that 30percent earn below ₹5,000, 60 percent bring in between ₹5,000 and ₹10,000, 8percent get between ₹10,000 and ₹15,000, and only 2percent take home above ₹15,000. Finally, the health status of the women respondents shows that 5percent have chronic health conditions, while 95percent do not experience any chronic health issues.

To determine whether women who benefit from monetary assistance from their spouses vary from the ones who do not in terms of unpaid work, emotional distress, and physical health decline, the 'Mann-Whitney U test' is employed.

H1a: Spousal financial support has an effect on UPW, ED and P

Table 1: Differences In Upw, Ed And P on The Basis of Spouse Financial Support

Comparison group	Items	U value	P value
Women receive spouse financial support Vs Women without spouse financial support	UNP	7730.500	0.913
	ED	7511.500	0.591
	P	7523.000	0.606

Table 1 findings disclose that the two groups' variations regarding these variables are not statistically relevant. The p-value for 'Unpaid work' (UPW) is 0.913, and the 'Mann-Whitney U' value is 7730.500. This value designates that there is an insignificant connection between spousal financial support and unpaid work contributions, displaying that the volume of unpaid work is unchanged for women independent of spouse financial support. The p-value for emotional distress (ED) is 0.591, and the 'Mann-Whitney U' value is 7511.500. This points out whether or not women benefit from monetary aid from their spouses, the impact on their mental suffering is the same. Both groups seem to have analogous degrees of emotional anguish. The p-value for physical health decline (P) is 0.606, and the 'Mann-Whitney U' value is 7523.000. Adding to the point, this suggests that there is no discernible difference in the two groups' decline in physical health.

To find out if the type of paid labor has substantial consequences on 'Unpaid work' (UPW), 'Emotional distress' (ED), and 'Physical health deterioration' (P), the 'Kruskal-Wallis test' was selected.

Table 2: Differences In Upw, Ed And P On The Basis Of Categories Of Paid Employment

Comparison group	Items	X ²	df	P value
CATEGORIES OF PAID EMPLOYMENT	UNP	5.595	4	0.232
	ED	5.285	4	0.259
	P	4.515	4	0.341

H2a: The burden of UPW, ED and P differs based on the category of employment.

With four degrees of freedom and a value for p of 0.232 in Table 2, the chi-square value for unpaid labor was 5.595. The p-value designates that the differences in UPW between different forms of paid labor are insignificant because it is higher than the significance level of 0.05. The test additionally produced a chi-square value of 5.285 with 4 degrees of freedom and a p-value of 0.259 for ED, hinting that the participants' degree of emotional discomfort is neutral to the type of paid labor. Also, the results disclose that respondents' degree of P is neutral to the kind of paid employment (p value=0.341>0.05, $\chi^2 = 4.515$).

To figure out if marital status (M_S) has a significant impact on 'Unpaid work' (UPW), the 'Mann-Whitney U' test was engaged.

H3a: Differences exist in UPW based on marital status.

Table 3: Differences in Upw on the Basis of Marital Status

Comparison group	Items	U value	Z Value	P value
SINGLE VS MARRIED	UPW	0.000	-14.760	0.000

Table 3 signifies that the amount of unpaid labor performed by women differs as per their marital statuses (Z value = -14.760; Mann-Whitney U value = 0.000) and it is statistically significantly. The negative Z value (-14.760) designates that married women are engaged in a lot more UPW than single people. Thereby, H3a is accepted (p-value =0.000<0.05) and it is to be pointed out that UPW differs with marital status of women.

The study deployed the ‘Mann-Whitney U’ test to determine if the family size greatly influences ‘Emotional Distress’(ED).

H4a: Emotional distress differs on the basis of family size

Table 4: Differences in Ed the Basis of Family Size

Comparison group	Items	U value	Z value	P value
SMALL VS LARGE FAMILY	ED	0.000	-14.439	0.000

Table 4 (Mann-Whitney U test = 0.000, Z = -14.439, p = 0.000<0.05) confirms that people with varying family sizes have statistically significant variations in the decline of their emotional wellness. The lower test scores and the negative Z value (-14.439) imply that those with smaller families often report higher degrees of ED. Thereby, H4a is accepted (p value =0.000<0.05) and signifies that family size does affect the emotional wellness.

To examine the link between educational qualification and emotional distress (ED), the study utilized ‘Kruskal wallis test’.

H5a: H5a: Emotional distress differs on the basis of the level of educational qualification

Table 5: Differences in Ed on the Basis of Educational Qualification

Comparison group	Items	X ²	df	P value
LEVEL OF EDUCATIONAL QUALIFICATION	ED	191.771	4	0.000

Table 5 indicates that the dependent component, emotional distress is considerably influenced by the grouping parameter, educational qualification (p-value of 0.000<0.05; Chi-Square value of 191.771; df=4), According to this statistically significant finding, various educational qualification levels' and degrees of emotional distress differ substantially. That is, emotional discomfort is significantly influenced by educational attainment, Hence, H5a is accepted

Measurement Model

Together with the corresponding indicators, the measurement model enumerated by the figure 2 details the linkages between three latent variables: “Unpaid Work (UPW)”, “Physical Health Deterioration (P)”, and “Emotional Distress (ED)”. The external loadings for each metric exceed the suggested benchmark of 0.7, indicating substantial reliability and a strong connection flanked by the latent variables and their observed measures.

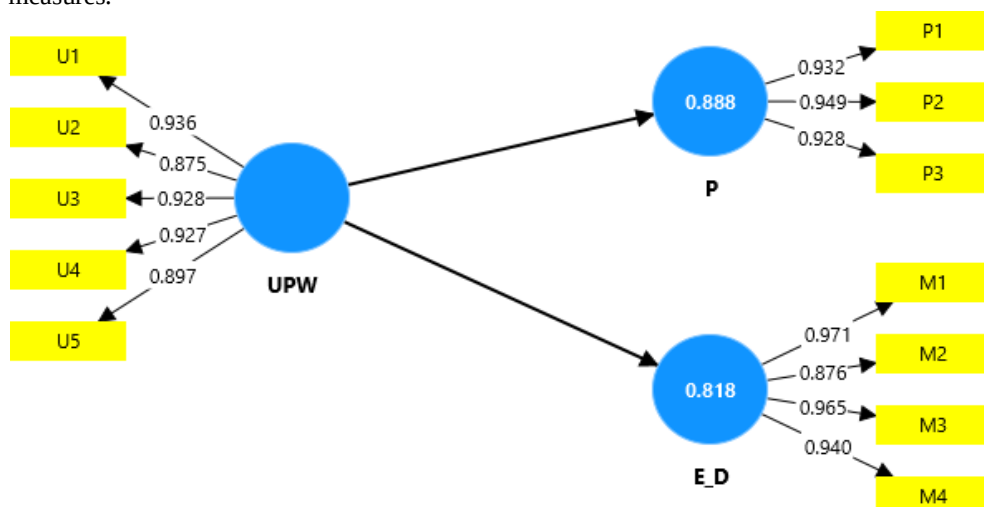


Figure 2: Measurement Model of ‘Unpaid Work induced Emotional and Physical Health’

‘Composite reliability’ (CR), ‘Average Variance Extracted’ (AVE) and ‘Cronbach’s Alpha’(CA) that test the reliability of are in Table 6. The test value benchmark for CR is that the values must be greater than 0.80 (Henseler and Fassolt (2010). The CR for the latent variables is above the benchmark (UPW=0.961; ED=0.967; P=0.955), The CA values are above the benchmark value of 0.70 (UPW=0.950; ED=0.955; P=0.930) in accordance with the guidelines of Hair et al (2011). In like manner, the AVE benchmark (UPW=0.833; ED=0.881; P=0.877) are greater than 0.50 as guided by Bagozzi and Yi (1988).

Table 1: Composite Reliability, Cronbach’s Alpha and AVE

	COMPOSITE RELIABILITY	CRONBACH’S ALPHA	AVERAGE VARIANCE EXPLAINED
ED	0.967	0.955	0.881
P	0.955	0.930	0.877
UPW	0.961	0.950	0.833

Table 7 renders the ‘factor loadings’ for the construct items. It is noticeable from the Table 7, that all the values of the constructs’ factor loadings surpassed the benchmark value of 0.7. Therefore, Convergent validity has been established.

Table 2: Factor Loadings of the constructs

	ED	P	UPW
M1	0.971		
M2	0.876		
M3	0.965		
M4	0.940		
P1		0.932	
P2		0.949	
P3		0.928	
U1			0.936
U2			0.875
U3			0.928
U4			0.927
U5			0.897

Table 8 details the Fornell-Larcker criterion, where in, the constructs fulfill the **Fornell-Larcker criterion** for discriminant validity and it reflects that the **square root of AVE for every construct** surpasses the **correlations** between the constructs.

Table 3: Fornell-Larcker criterion for the constructs

	ED	P	UPW
ED	0.939		
P	0.896	0.936	
UPW	0.904	0.942	0.913

Each construct outlines a significant amount of variance in its indicators, all of which surpass the 0.50 threshold, confirming adequate convergent validity. The crossways values, ED (0.939), P (0.936), and UPW (0.913), symbolize the square root of the AVE for each construct. The correlations amid the constructs are designated by the off-diagonal values, which point towards strong to exceptionally strong relationships: ED and P (0.896), ED and UPW (0.904), and P and UPW (0.942). A construct is deemed to be unique as per the rule of Fornell-Larcker, when the AVE’s square root for every construct is larger than its correlations with any other construct. The constructs in the table 8 demonstrates that all of them accounts for a considerable portion of the variation in their separate indices and are fairly unique from one another.

Structured Model

The ‘Standardized Root Mean Square Residuals’ (SRMR) value, if less than 0.10, is considered acceptable, and if the values are less than 0.08, it denotes an excellent model fit. The study's SRMR value was very close to the conservative benchmark of 0.08, illustrating a strong fit in the model. The SmartPLS output's R² values show how well the model explains the variables that are endogenous. The R² value for P (0.888) featured in fig.3,

signaling an excellent match as the predictive model accounts for 88.8percent of the variation in this construct. The R^2 value for ED (0.818) contained in the figure 3, meaning that the model accounts for 81.8percent of the variation in ED. illustrating an excellent model fit and robust predictive power, these high R^2 values show that the model explains a significant portion of the variation in both P and ED.

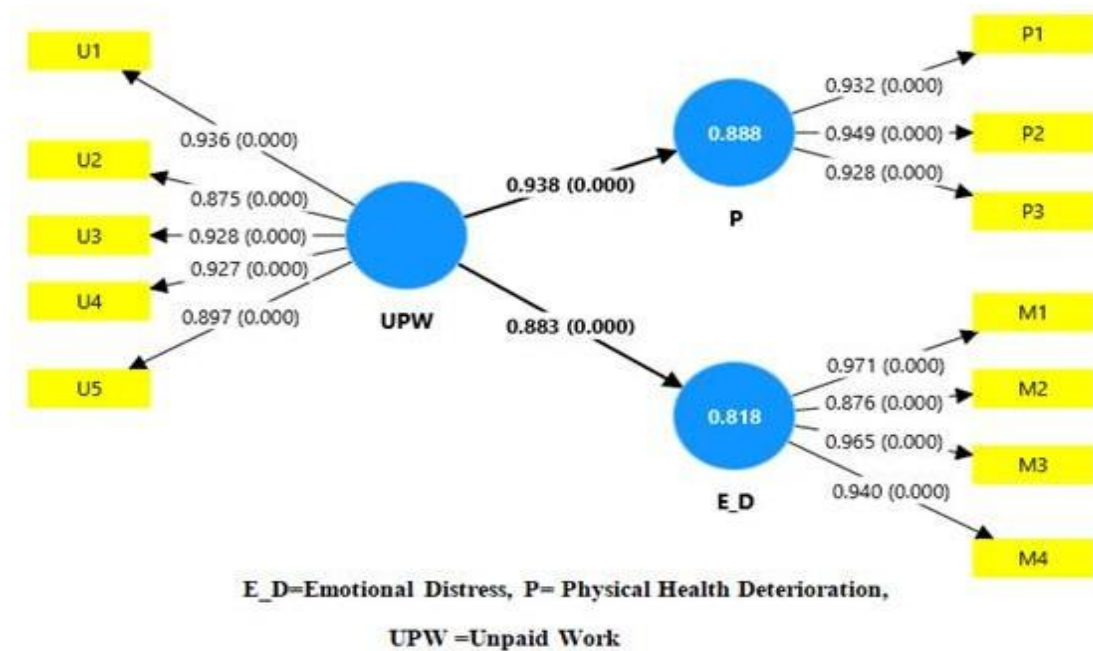


Figure 3: Structured Model of 'Unpaid Work induced Emotional and Physical Health'

In continuation, hypotheses relationships and the outcome were tested, table 9 and figure 3 compiles the tested values, it was confirmed that 'Unpaid Work' had a positive and statistically significant impact on 'Emotional Distress' ($b=0.883$, $t=42.235$, $p=0.000<0.05$), following which, H6a was accepted. More to the point it was unveiled that 'Unpaid Work' had a positive and statistically significant effect on 'Physical Health Deterioration' ($b=0.938$, $t=64.438$, $p=0.000<0.05$), consequently H7a was also accepted.

Table 4: Path Coefficients of UPW, ED and P

Hypotheses	LINK	B	t	p
H6a	Unpaid work → Emotional Distress	0.883	42.235	0.000
H7a	Unpaid work → Physical Health Deterioration	0.938	64.438	0.000

Building on these findings, it is to state that there is pragmatic significance in the links between "Unpaid Work" and the outcomes "Physical Health Deterioration" and "Emotional Distress." The statistically noteworthy p-values and high t-values clarify the strength of these correlations, which means that unpaid labor has a considerable and meaningful effect on people's cognitive and corporal health.

Discussion

The study investigates the connection of unpaid work with emotional distress and physical health deterioration of women working for unorganized sector in North Chennai. This study places the interest that the demands of unpaid work noticeably affect cognitive and general wellbeing. The review accentuates the pressure of unpaid work on emotional distress and physical health deterioration of women. Women typically lumber with unpaid work, which may worsen mental health due to time constraints and multiple responsibilities. Lightening the psychological health risks which was linked with unpaid work should be a main concern. The results highlight that no considerable differences in 'unpaid work', 'emotional distresses', or 'physical health deterioration' between women receiving spousal monetary support and those who do not. This suggests that financial aid alone is insufficient to lessen the burden of unpaid work, emotional distress and physical mental deterioration. Unpaid work, emotional distress and physical mental deterioration are similar irrespective of occupational roles and the challenges related with unpaid labor remain omnipresent and even across employment categories. A significant difference in unpaid work based on marital status and physical health deterioration based on family size was observed, the results uncovered the fact that unpaid work differs as per the marital status of women. Married women are taxed with more unpaid work than single women. Family size also explains the emotional distress of

women, there is a difference observed that there is an increase in the emotional distress as women commits to do unpaid work to her family. These findings emphasize the inevitability for policies that address not only the economic aspects but also the social determinants that aggravate gender disparities in connection with unpaid work. The structural model confirms the deep repercussion of unpaid work on emotional distress and physical health deterioration, with statistically significant beta values. These results corroborate the hypothesis that unpaid labor contributes notably to adverse mental and physical health outcomes. Together, these findings accentuate the urgent need for systemic interventions, such as equitable distribution of domestic errands and better social support mechanisms, to alleviate the multifaceted consequences of unpaid labor on women's well-being.

In accordance with the study's findings, it could be recommended that effective social security programs should guarantee basic healthcare, pecuniary stability, and support throughout the life cycle. By reducing unpaid labor, public services like convincingly priced daycare and enhanced electricity and water infrastructure can let women to participate more fully in the workforce and in public activities. The government must make sure that public are endowed with communal daycare programs, or parents may be required to co-pay. Every family, regardless of financial situation, might have right of entry to these public childcare centers. Affordable elderly care and rationally charged household services can considerably shrink the saddle of unpaid care work. As there is an unequal sharing of household tasks between the genders, it encumbers women's participation in the workforce. It is important to provide generous parental leave for fathers in order to promote a more equitable sharing of domestic responsibilities. These types of policies have medium term effect but can bring positive impacts on the distribution of domestic work among men and women (Kabeer & Waddington, 2021). Financial literacy is crucial, as it bring into line with the bargaining framework according to Kim et al (2017), which put forward that individuals who are more financial informed enjoy greater bargaining power in family decisions and are less likely to involve in unpaid work. It is noteworthy to state that North Chennai women who work for unorganized sector face unique challenges as they live with a blend of urban living and conventional cultural norms. While they live an urban lifestyle, their customs and culture remain conventional. These women are dedicated to both unpaid family work and the work they do for pecuniary support. When devising policies, the government should think about the unique lives of women in North Chennai and widen inclusive policies that concentrate on their specific needs and circumstances. Policies must be customized to address these challenges, providing social support and prospects that allow North Chennai women to thrive both at work and within their families. Women would be assured equal chances and acknowledgement for their economic contributions if unpaid labor were incorporated into national macroeconomic policies and laws. Incorporating inquiries regarding unpaid labor into national surveys, like the Census, is essential. This would guide policy decisions and give a better knowledge of how unpaid labor affects women's mental and physical health..

The study has certain limitations. First, female participants were lacking self-assurance to discuss the issue of unpaid work. Second, many women respondents felt guilty about addressing their responsibilities related to child care. Third, it was challenging to explain the concept of unpaid work to participants. Lastly, the findings may not be generalized, as the study incorporated participants who work in the unorganized sector in North Chennai. Future research could spotlight on longitudinal studies to better comprehend the link connecting unpaid work and women's cognitive and general well-being. A comparative study could also look into the force of unpaid work on women in both the organized and unorganized sectors, exploring its alliance with other related variables. Further research could direct consideration to better understand these relations and the mechanisms that drive them.

Conclusion

Unpaid work significantly has repercussions on women's emotional distress and physical health deterioration, often culminating in stress and limited personal time. This study highlights a clear link between unpaid work of North Chennai Women working under unorganized sector, their emotional distress and physical health deterioration. The results can guide future initiatives aimed at improving these women's status in the community. Elevating societal consciousness and educating the society about the pivotal role of women in the community is essential.. Therefore, it's essential to provide women with societal support frameworks that allow them to apply their expertise and talent in their workforce without jeopardizing family obligations or personal well-being.

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An Empirical Examination of Six-Factor Asset Pricing Model and Stock Market Anomalies in Emerging Equity Markets of India and Korea

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Abstract

Presence of anomalies in stock market is very evident but their existence is coupled with the asset pricing model used to estimate normal returns on the stocks. The domain of return estimation models is still evolving and there is no consensus on one parsimonious model suitable for all asset classes or countries. It creates a need for revisiting the anomalies in light of Six-factor asset pricing model which in our study adds the turnover or liquidity factor to the Fama-French Five-factor model. This study analyses the equity anomalies in India and Korea, the leading emerging markets as per equity market capitalization. The equity stock market data during an eight-year horizon of July 2015 - June 2023 is comprehended to find the anomalies using the six-factor asset pricing model built on the Fama & French approach. It is a turnover augmented Fama-French Model. Hundred (25×4) quintile dependent portfolios of companies listed at the leading stock exchanges of the two countries - National Stock Exchange and Korea Stock Exchange, were formulated on 30th June each year using bivariate sorting. The multiple cross-sectional regression of monthly returns of the portfolios on independent factor variables yields alpha returns and beta coefficients for the select anomalies – size, value, profitability, investment and turnover. Presence of excess or abnormal returns on bivariate dependent portfolios is an indicator of presence of anomalies in India and Korea. The results show prevalence of only profitability effect and turnover effect in India, whereas, Korea depicts all but turnover anomaly. The profitability anomaly has the highest return in both the emerging markets. The liquidity-augmented Fama-French Five Factor model seems relevant for the both equity markets but performs better for Indian markets. The new model is capable of explaining majority of portfolio returns in this study. It implies that investors need to shift to six-factor model to estimate expected returns of their portfolios rather than the traditional models. The policy makers of these countries need to take into account the anomalies while taking initiatives to enhance the market microstructure of stock exchanges. This study also creates a base for further research in this field because some anomalies are surviving even after the six-factor model. There is scope for creating and testing new models especially for emerging markets.

Keywords: Stock market anomalies, Emerging markets, Multifactor asset pricing model, Market efficiency, turnover effect.

Introduction

It is evident that risk-return trade-off is the precursor of all investment decisions in financial markets. It means high risk securities must yield commensurately high return to the investor. Traditional models like Capital Asset Pricing Model (CAPM) state that expected return of security is a linear function of risk. However, investors are still able to beat the market by contrasting rational theory of investment. Investors in real market formulate profitable trading strategies based on numerous other non-risk factors, viz. company fundamentals, economic conditions, personal knowledge, intuition & experience, analyst recommendations, seasonal patterns, etc. Presence of anomalies related to size, value, profitability, liquidity, prior return patterns, under-reaction or overreaction, etc implies either market inefficiency or a mis-specified asset pricing model. Therefore, discovery of a parsimonious model to explain equity returns will enhance formulation of fool-proof trading strategies for investors.

On the estimation model front, Fama-French Three Factor model is a great progress over CAPM by inculcating size and value factors as explanatory variables but it still is not able to completely explain expected returns universally. So, the research journey continues to look for missing factors to increase explanatory power of asset pricing models. Fama-French Five Factor model is the most recent framework which is still under testing by current researchers. This paper thus augments literature in this area by researching on presence of stock market anomalies in select emerging markets and their dynamics with asset pricing models. India and Korea are amongst the top five largest emerging stock markets by market capitalization. Moreover, they have a nearly comparable size also. China, being multiple times in market cap, was left out from the sample. Saudi Arabia, though similar in size, has scant data available to support research. So, this leaves us with the two sample countries chosen. Emerging economies are a cynosure of global investors for high returns and risk

diversification. So, research results will assist global fund managers, analysts, investors and policy makers in portfolio construction, diversification and policy formulation respectively.

Literature Review

The whole story of anomalies in equity share market begins with asset pricing models used to predict the normally expected return on the equity share. Asset pricing models date back to 1952 when Harry Markovitz propounded Mean-Variance efficient portfolio theory which established a link between security return and its risk. It was extended by William Sharpe in 1964 with his Single index model which used market return as the only explanatory variable for a security's return. Thereafter, CAPM set forth a linear cross-sectional relationship between expected return and systematic risk (beta) of the security. However, CAPM was under constant testing and scrutiny for not being able to explain security returns in certain cases.

Major contradictions to CAPM were Banz (1981), Statman (1980) DeBondt & Thaler (1985) and others. Such instances where security returns can't be fully explained by estimation model are called as anomalies. Equity anomalies like size, value, prior return are heavily documented whereas there is scarce research on liquidity, profitability, turnover, accruals, etc. Size of a firm inversely affects its stock's average returns. According to Banz (1981), firms with lower market value yield higher securities return, i.e., small firms outperform large firms. Value anomaly is presence of higher returns in firms with high Book equity-to-Market equity ratio. [Statman (1980)]. Such value stocks can also be identified using Earnings to Price ratio [Basu (1983)] or Dividend to Price Ratio [Bhandari (1988)]. It is the tendency of value stocks to outperform growth stocks. Value effect is well documented and accepted, however, debate continues about what explains value premium.

Table: 1 Existing Asset Pricing Models

Model	Equation
CAPM	$R_i = R_f + \beta_i[R_m - R_f] + \mu_i$
Single Index	$R_i - R_f = \alpha_i + \beta_i[R_m - R_f] + \mu_i$
Fama-French Three Factor Model	$R_i - R_f = \alpha_i + \beta_i[R_m - R_f] + s_iSMB_t + h_iHML_t + \mu_i$
Fama-French Five Factor Model	$R_i - R_f = \alpha_i + \beta_i[R_m - R_f] + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + \mu_i$

Source: Authors' compilation

Presence of CAPM anomalies led the researchers to find a new asset pricing model which could absorb size and value premium. Fama-French Three Factor Model (FFTF) (1996) is capable of explaining many previously reported anomalies by expanding CAPM with size and value factors. Inclusion of size and value coefficients in asset pricing model enabled it to completely justify security returns and thus solve the question of equity anomalies.

However, the respite from anomalous returns was short and in no time many other equity anomalies were discovered. Various other firm characteristics like Liquidity, Accruals, Stock repurchases, Stock issues, Profitability and Investments are also proven to affect security returns. Amihud & Mendelson (2002), Hwang & Lu (2007) find that investors demand premium for less liquid firms. There is a negative relation between liquidity of stock in market and its stock returns. When tested on emerging markets, liquidity augmented FFTF model does well only in Indian Context. (Sehgal et. al. 2014)

Profitability, undoubtedly, is a determinant of security returns. However, there are contrasting theories which state that the relation may be positive (mature markets) or negative (developing markets). Fama-French (2008) has incorporated it in their asset pricing model using Return on Equity as a proxy. Returns on a security depict earnings of the firms which are closely dependent on its investment decisions. Fama & French (2006) as well as Singh & Yadav (2015) demonstrate an inverse relation between investment by a company and its stock returns. A high ratio depicts aggressive investment while a low ratio shows conservative investment.

Similar results across nations and time period on equity anomalies called for a revision of our traditional risk based models. Therefore, after almost a decade of its birth, Fama-French Three Factor model has further been augmented to Fama-French Five Factor Model (FFFF) by inculcating profitability and investment factors. However, the FFFF model is still being subject to rigorous testing and research for universal applicability and reliability. Sehgal et. al (2014) and Singh & Yadav (2015) find that FFTF model is still working well in India and other emerging markets. Five factor model does better when portfolios are formed on variables not included in three factor model. Some other prominent works are Maiti & Balakrishnan (2018) Das & Mahakud (2015) which presents a comprehensive picture on asset pricing models and anomalies in Indian stock markets. All the anomalous relations of CAPM and FFTF model and limitations of Five-factor model call for further research to build a robust multifactor model.

As evident in all the studies referred above, prominent anomalies like size, value, prior return and accruals have been intensively researched in emerging markets but others are yet to find some depth in their empirical

evidence. Some great advancement in this direction has been Patel (1988), Rowenhorst (1999), Pasaribu (2009), Vu (2012), Hoffman (2012), Chen, Kim, Yao & Yu (2010), Sobti (2018) and Pandey (2020).

Concurrent research is underway on development of a Multifactor asset pricing model in context of Emerging markets. Balakrishnan, Maiti and Panda (2018) concluded that all the four firm fundamentals used in five factor asset pricing model are a significant determinant of returns. It states that the FTF model still holds ground despite of various multifactor models being developed recently. Singh & Yadav (2015) presents a comparative view of CAPM, FTF, Fama French Five Factor model on Indian stock markets by using time series hierarchical multiple regression on CNX 500 companies during 1999-2014. Four factor model (excluding investment) is better than FTF model. Sehgal, Subramaniam & Desting (2014) tests prominent equity market anomalies for six emerging markets, namely, Brazil, India, China, South Africa, Indonesia and South Korea. Its results based on Fama French Three Factor Model show that size, value and liquidity anomaly is present in Korea, while size, momentum and stock repurchases anomaly is revealed in India. Dedicated research is also available on both the countries. Pandey (2020) studied the five popular anomalies in Indian equity market from July 2001 to June 2019 and found that though all the anomalies - size, value, profitability, investment and momentum are present in Indian markets, the size and value anomaly yield substantially significant returns. It found three factor model to be the relevant model for India as CAPM fails to explain alpha while the four and five factor model don't add any explanatory power to stock returns.

Han, Lee and Kang (2020) worked on 148 anomalies to study the performance of the Korea Stock Exchange. They found 57 equity anomalies to have statistically significant returns at 5% level of significance. They emphasise on the role of microcap stocks on anomaly returns. The study suggests use of value weighted portfolios and exclusion of microcaps from the sample. It gives pertinent conclusion related to tactical asset allocation by use of equity anomalies in a creative way, for instance, factor returns are cyclical and thus can be used on rotation basis to build profitable strategies. Kim, Kang and Roh (2024) tests the presence of 26 anomalies in Korea using a mispricing measure. It finds that trading behaviour of individual investors (noise traders) generates anomalies. The institutional investors and foreign investors are more sophisticated than retail traders and thus make profits using anomalies. The review of literature gives insight about the need to study anomalies in light of a more relevant asset pricing model which is capable of explaining security returns.

Research Questions

In light of the survey of literature and thought process developed thereafter, this research has the following questions:

- To re-examine the presence of select equity anomalies in India and Korea.
- To examine if Six factor model can explain stock returns in India and Korea.
- To find a parsimonious multifactor asset pricing model to explain security returns India and Korea.

Data & Research methodology

The population of interest for this research is emerging economies of the World. Using various parameters like size of economy, five leading emerging economies identified are China, India, Saudi Arabia, South Korea and Taiwan. China, being multiple times in market cap, was left out from the sample. Saudi Arabia, though similar in size, has scant data available to support research. So, this leaves us with the two sample countries chosen. India and Korea have a nearly comparable size also. The paper analyses presence of prominent anomalies – size, value, profitability, investment and turnover, using the six factor model.

Data for the study will comprise of monthly closing stock prices of all the companies listed on leading stock exchanges – National Stock Exchange (NSE) and Korea Stock Exchange (KSE). Risk free rate of return will be proxied by country-specific short term interest rates as available on the website of OECD (Organisation for Economic Co-operation and Development). It is an additional contribution of this paper over available literature which uses US treasury-bill (t-bill) rate for all emerging markets. Authors believe that use of US treasury bill rate will result in underestimation of excess returns because interest rates are on higher side of spectrum for emerging markets viz.-a-viz. developed nations like US. Independent variables used in the study are proposed to be measured as follows:

Table: 2 Independent factor variables and their measurement

Variable	Metric
Market	Return Premium
Size	Market Capitalization
Value	Price to Book Ratio
Profitability	Return on equity
Investment	Change in assets to total assets ratio
Turnover	Trading Volume (as % of market float)

Source: Authors' compilation

Methodology involves creation of double-sorted quintile portfolios using the five variables chosen for the study. The asset pricing model used should be able to explain the average portfolio returns. Presence of abnormal portfolio returns, i.e., in excess of expected returns indicates towards existence of an anomaly. The whole research design uses multiple regression tools and portfolio formulation as per Fama-French (2015) methodology.

All the securities in a market are sorted on a chosen variable, say, size on 30th June each year. Using Fama-French approach, Median is used for first bifurcation based on size and then within large size companies, 30th and 70th percentile is used to create 3 portfolios. This gives 6 (2×3) independent portfolios. Secondly, 25 (5×5) dependent portfolios are created using double sorting and quintiles. Monthly portfolio returns are then calculated from closing stock prices for the period of July to June of next year.

Independent factor variables are computed as follows:

SMB = Average return of 12 small stock portfolios - Average return of 12 large stock portfolios

$$SMB \text{ (Small Minus Big)} = \frac{1}{3} (SMB_{VAL} + SMB_{PROF} + SMB_{INV} + SMB_{TURN})$$

$$\begin{aligned} \text{Where, } SMB_{VAL} &= \frac{1}{3} (SV + SN + SG) - \frac{1}{3} (BV + BN + BG) \\ SMB_{PROF} &= \frac{1}{3} (SR + SN + SW) - \frac{1}{3} (BR + BN + BW) \\ SMB_{INV} &= \frac{1}{3} (SC + SN + SA) - \frac{1}{3} (BC + BN + BA) \\ SMB_{TURN} &= \frac{1}{3} (SI + SN + SL) - \frac{1}{3} (BI + BN + BL) \end{aligned}$$

Similarly,

$$\begin{aligned} HML \text{ (High Minus Low)} &= \frac{1}{2} (SV + BV) - \frac{1}{2} (SG + BG) \\ RMW \text{ (Robust Minus Weak)} &= \frac{1}{2} (SR + BR) - \frac{1}{2} (SW + BW) \\ CMA \text{ (Conservative Minus Aggressive)} &= \frac{1}{2} (SC + BC) - \frac{1}{2} (SA + BA) \\ IML \text{ (Illiquid Minus Liquid)} &= \frac{1}{2} (SI + BI) - \frac{1}{2} (SL + BL) \end{aligned}$$

Thereafter, dependent portfolio returns are regressed on factors using six factor model. The excess returns on each of the portfolio must be fully explained, otherwise it indicates towards presence of anomaly.

$$R_i - R_f = \alpha_i + \beta_i [R_m - R_f] + s_i SMB_t + h_i HML_t + r_i RMW_t + i_i CMA_t + \mu_i$$

..... (Fama French Five Factor Model) (Equation 1)

Similar procedure is followed for rest of the variables also. To test for turnover anomaly, i.e., less liquid stocks outperform more liquid stocks, the above equation is applied on liquidity sorted portfolios. In presence of the anomaly, equation 1 is extended by adding a liquidity factor (IML_t) as in the following equation:

$$R_i - R_f = \alpha_i + \beta_i [R_m - R_f] + s_i SMB_t + h_i HML_t + r_i RMW_t + i_i CMA_t + l_i IML_t + \mu_i$$

..... (Six Factor Model) (Equation 2)

Hypotheses

This study uses the following alternate hypotheses to answer its research questions:

- H1:** Stocks of small firms outperform those of large size firms.
- H2:** Stocks of value firms (low P/B ratio) outperform those of growth firms (high P/B ratio).
- H3:** Stocks of weak profitability firms outperform those with robust profitability.
- H4:** Stocks of firms with low investment outperform those with high investment.
- H5:** Less Liquid stocks outperform more liquid stocks.
- H6:** Six-factor asset pricing model can fully explain returns on stocks.
- H7:** Six factor asset pricing model performs better than Fama-French Model(s).

The first five hypotheses correspond to the first research question and so on for the second and third research question.

Results & Empirical Discussion

The discussion on results of generalised least square regression are presented in this section. In each table, 25 dependent portfolio regression coefficients and intercepts are mentioned with their p-values. The portfolio 1 being winner portfolio and portfolio 5 being loser portfolio in all cases of value, profitability, investment and turnover. Prima facie, anomalies are more prominent in Korean markets. Small company portfolios show

significantly high return in Korea only. This is a marked departure from past literature which shows size effect in India. It may be due to use of a true representative as risk-free rate of return which is higher than the US t-bill rate used in past literature. It has led to disappearing of size effect. Indian stock markets show only profitability and turnover effect. It means the high earning numbers and low stock turnover in the trading market is a good identifier of investment options in Indian Stock markets. As expected, market premium is still the prominent factor represented by highly significant p-value in both the countries. On the other hand, Korean stock markets seem to be characterised by all anomalies except turnover effect.

Univariate results shown in descriptive statistics (Table 3) point towards positive excess returns on all anomalies in Korea. Profitability effect yielding the highest returns to the tune of 1.02%. Small firms yield 0.51% more than the large firms. Value investing in Korean markets is also equally promising because it gives 0.64% more by investing in low P/B value stocks than high P/B stocks. Equity of firms with conservative investment strategy earns 0.46% more returns than those with aggressive investment strategy. It implies that we can reject the first four null hypotheses for Korea.

Table: 3 Average factor returns and their p-value

Mean and S.D. of factor returns						
INDIA	Mrkt	SMB	HML	RMW	CMA	IML
Mean	-4.913	0.5547	0.3489	0.6778	-0.0329	0.5185
S.D.	6.3903	3.9816	3.2432	2.8507	1.8279	2.6536
S.E. (mean)	0.6527	0.4067	0.3313	0.2912	0.1867	0.2711
t (mean)	-7.533	1.3649	1.054	2.3295	-0.1764	1.9145
p-value	0.00	0.18	0.29	0.02	0.86	0.05
KOREA						
Mean	-1.5161	0.5104	0.6439	1.0219	0.4568	0.0141
S.D.	6.6778	2.4057	2.9296	2.4232	1.9428	2.9371
S.E. (mean)	0.6821	0.2457	0.2992	0.2475	0.1984	0.3000
t (mean)	-2.2244	2.0789	2.1536	4.1319	2.3036	0.0469
p-value	0.03	0.04	0.03	0.00	0.02	0.96

Source: Authors' Calculation

So, Korean stock markets have presence of the four anomalies – size, value, profitability and investment. Whereas, p-value for fifth hypothesis is 0.96 so we don't reject the null hypothesis that stock returns of illiquid firms outperform liquid firms. Our results deny presence of turnover effect in Korea. Indian markets also reveal a strong profitability effect with average excess returns of 0.68% having a p-value of 0.02. Similarly, investors can also make more money by investing in firms having low liquidity in stock markets. A p-value of 0.05 makes the turnover effect significant. Therefore, our results reject third and fifth null hypothesis for Indian Stock markets.

Refer Table 4 here

Turnover factor being significant in one of the countries gives ample ground for testing its ability to explain security returns. We test the sixth hypothesis that six factor model can explain security returns. In panel A of Table 4, the absence of significant alpha in majority of the 100 dependent portfolios shows that at 5% level of significance, we reject the null hypothesis – “six factor model can't fully explain security returns”. So, the six-factor model developed by augmenting Fama-French five factor model with turnover factor is found suitable to explain the return in all the case of size-value portfolios, size-investment portfolios, size-profitability portfolios and size-turnover portfolios. However, as an exception, highly significant p-values in corner portfolios indicates six factor model has difficulty explaining high returns generated by some of the lowest and highest quintiles. The beta coefficients and size coefficient are significant in all cases so, market premium and size of company still remain the most prominent explanatory variable for security returns. The value coefficients are mostly significant towards the section of low P/B ratio portfolios only. It means that the new model is not suitable for growth stocks. The new addition to this list is the turnover factor which comes out to be significant in most Indian portfolios. The turnover coefficients are mostly negative and significant (p value < 0.05) which means that there is an inverse relation between liquidity in stock market and stock's returns. An additional observation pinpoints an investment strategy for readers. In panel B, the intercepts of the model are significant at 5% level for corner portfolios representing small size-growth stocks and big size-value stocks. Similarly, in Panel D, small size-illiquid stocks generate significant excess returns for investors in Indian stock markets.

The value factor and investment factor seem to be present but weak in Indian stock markets as the results show only a few significant coefficients. Profitability factor is also not very significant in explaining returns in Indian stock markets. Though weak profitability firms are showing significant profit coefficients irrespective of size of

the firm, but size-profitability portfolios depict insignificant profit coefficient. The intercept on size-profitability sort portfolios is not significant for 22 out of 25 portfolios in panel C below. The turnover or stock liquidity factor has explanatory power because the six factor model is able to explain 24 out of 25 size-turnover sorted portfolio returns shown in panel D.

Refer Table 5 here

Moving on to Korean counterpart of Indian stock markets, the first observation is that in Korean stock market, there is presence of significant excess returns on 51 out of 100 portfolios. So, the investors have wider options for formulating their investment strategy based on anomalies. Panel A of Table 5 shows results for regression run on size-value double sorted portfolios. Six factor model gives mixed results here. It seems successful to a large extent in explaining small and big portfolio returns though the middle quantiles show unexplained returns. In panel B, C and D of Table 5, results present a different picture where the six factor model doesn't seem to do well for middle sized quintiles of dependent portfolios. Similar to the factor variable results, turnover anomaly is found to be significant at 5 % level for majority of dependent portfolios created based on size-value, size-investment, size-profitability and size-turnover sorting of Korean stocks. Turnover factor is significant for 73 out of 75 bivariate portfolios created using factors other than turnover. This depicts the relevance of turnover, as an indicator of liquidity, in creation of the Six factor model. Therefore, we don't have a strong evidence to reject the sixth null hypothesis in Korean markets. The six factor model is not able to fully explain all portfolio returns in Korea.

Refer Table 6 here

The six factor pricing model performs poorer in Korean market as is evident from the significant intercepts of regression equation indicating presence of unexplained excess returns on Korean stocks. Size-turnover sorted portfolios are promising here also as shown by highly significant turnover coefficient, especially for illiquid portfolios. Lastly, the average values of Adjusted R^2 of regression equations is lower for Korean stock portfolios when compared to Indian Stock portfolios. Table 6 shows comparative analysis of the three-factor model, five factor model and the six-factor model used in the study. Results indicate that, on an average, six factor model can explain 83% of the portfolio return in India whereas only 74% of return is explained by the six factor model. It can be concluded that the Six-factor model performs better for India while there is only marginal improvement for Korea.

Conclusion & Future scope

This study done on eight years' data of National Stock Exchange and Korean Stock Exchange gives useful insights on equity market anomalies of these two leading emerging stock markets. The empirical results throw sufficient light on the objectives of the study. The results show prevalence of only profitability effect and turnover effect in India, whereas, Korea depicts all but turnover anomaly. The profitability anomaly has the highest return in both the emerging markets. The new model is capable of explaining majority of portfolio returns in this study. It implies that investors need to shift to six-factor model to estimate expected returns of their portfolios rather than the traditional models. This research work also tells that the turnover augmented six factor model is performing better in explaining returns on securities in India as compared to Korea. When looking at Korean markets, the abnormal returns are lower than India but all the anomalies except turnover are present in their stock markets. So, this study concludes that the emerging markets still show asset pricing anomalies. It implies that investors and portfolio managers can exploit them to generate higher investment returns. Moreover, the policy makers of these countries need to take into account the anomalies while taking initiatives to enhance the market microstructure of stock exchanges.

ANNEXURES

Table:4 Regression Coefficients of Six Factor Model on 25 Indian portfolios

Panel A Size-value portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-1.0735	-0.3544	-0.5995	-0.4329	-0.3155	0.01	0.43	0.16	0.35	0.43
2	-0.1697	-0.5041	-0.0160	0.2890	-0.2329	0.68	0.30	0.97	0.55	0.60
3	-0.2876	-0.0181	-0.1342	-0.0865	-0.4870	0.52	0.97	0.77	0.85	0.30
4	0.1371	-0.2134	-0.4375	-0.0733	-0.6464	0.78	0.64	0.42	0.86	0.17
Big	-0.2519	-0.4485	-0.2361	-0.3033	-0.8312	0.51	0.16	0.42	0.39	0.02
	Beta					p value				
Small	0.8546	1.0024	0.9104	0.9259	0.8611	0.00	0.00	0.00	0.00	0.00
2	1.0095	1.0599	1.0726	1.0850	1.0497	0.00	0.00	0.00	0.00	0.00
3	1.0085	1.0950	1.0799	1.0903	1.0424	0.00	0.00	0.00	0.00	0.00
4	1.1463	1.0098	0.9833	1.0284	1.0135	0.00	0.00	0.00	0.00	0.00
Big	0.9989	0.9546	0.9251	0.9869	0.8861	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	1.4656	1.7641	1.9070	1.5850	1.5285	0.00	0.00	0.00	0.00	0.00
2	1.3405	1.1933	1.2845	1.3702	1.2952	0.00	0.00	0.00	0.00	0.00
3	0.6805	0.9011	0.9265	0.9121	1.1992	0.00	0.00	0.00	0.00	0.00
4	0.3516	0.3975	0.5417	0.5374	0.5622	0.02	0.00	0.00	0.00	0.00
Big	-0.0373	0.1810	0.2612	0.2562	0.3537	0.74	0.05	0.00	0.01	0.00
	H					p value				
Small	0.8824	0.4571	0.2444	0.3226	0.0634	0.00	0.05	0.26	0.18	0.75
2	0.6026	0.6426	0.5599	-0.0470	-0.0149	0.00	0.01	0.03	0.85	0.95
3	1.1874	0.6235	0.5745	0.2322	-0.1302	0.00	0.01	0.01	0.30	0.59
4	0.9473	0.7263	0.3634	0.1830	-0.0529	0.00	0.00	0.19	0.39	0.82
Big	0.8289	0.2540	-0.0279	-0.1811	-0.4673	0.00	0.11	0.85	0.31	0.01
	P					p value				
Small	-0.5803	-0.3358	-0.2438	-0.1296	-0.4512	0.01	0.14	0.27	0.58	0.03
2	-0.5339	0.0913	0.1985	-0.1526	-0.0214	0.01	0.71	0.43	0.54	0.93
3	-0.3212	0.1098	-0.1460	-0.2768	-0.3898	0.16	0.66	0.53	0.22	0.11
4	-0.0236	-0.0320	-0.3315	-0.5148	-0.2087	0.93	0.89	0.23	0.02	0.38
Big	-0.1357	-0.1730	-0.1959	-0.2265	-0.1663	0.49	0.28	0.19	0.20	0.36
	I					p value				
Small	0.3398	0.3934	0.4817	0.5321	0.5982	0.23	0.18	0.08	0.08	0.02
2	0.8541	0.1020	0.5407	0.6727	0.4749	0.00	0.75	0.09	0.03	0.10
3	0.7521	0.7253	0.9078	0.7991	1.0607	0.01	0.03	0.00	0.01	0.00
4	0.4453	0.5354	0.9196	0.7959	0.5194	0.17	0.07	0.01	0.00	0.09
Big	0.2800	0.3742	0.4606	0.3778	0.0639	0.26	0.07	0.02	0.10	0.78
	T					p value				
Small	0.2888	-0.0814	-0.3859	-0.3503	-0.2125	0.03	0.56	0.00	0.02	0.09
2	-0.6010	-0.5028	-0.6826	-0.7484	-0.5076	0.00	0.00	0.00	0.00	0.00
3	-0.6248	-0.5149	-0.7069	-0.6291	-0.6756	0.00	0.00	0.00	0.00	0.00
4	-0.6807	-0.4956	-0.5311	-0.4405	-0.4068	0.00	0.00	0.00	0.00	0.01
Big	-0.5549	-0.2654	-0.3047	-0.0707	-0.1528	0.00	0.01	0.00	0.51	0.17

Source: Author's calculation

Panel B Size-Profitability portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-0.0895	0.2755	-0.5224	-0.6345	-1.8348	0.86	0.53	0.28	0.15	0.00
2	0.0382	-0.3134	0.0553	-0.2532	-0.1432	0.94	0.48	0.91	0.60	0.77
3	-0.0666	0.0257	0.0592	-0.1479	-0.8805	0.89	0.96	0.90	0.75	0.06
4	-0.9025	-0.3027	-0.0901	-0.0206	0.0849	0.07	0.51	0.86	0.96	0.58
Big	-0.9103	-0.6204	-0.5098	-0.3868	0.2809	0.05	0.05	0.09	0.18	0.48
	Beta					p value				
Small	0.9026	0.9619	0.9148	0.9372	0.8322	0.00	0.00	0.00	0.00	0.00
2	1.0844	1.0253	1.1234	0.9726	1.0697	0.00	0.00	0.00	0.00	0.00
3	1.1163	1.1099	0.9972	1.0676	1.0279	0.00	0.00	0.00	0.00	0.00
4	0.9902	0.9681	1.0521	1.0789	1.0955	0.00	0.00	0.00	0.00	0.87
Big	0.9238	0.9481	0.8892	0.9607	1.0174	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	1.6044	1.6591	1.5616	1.7152	1.7164	0.00	0.00	0.00	0.00	0.00
2	1.2995	1.3816	1.3314	1.1725	1.2977	0.00	0.00	0.00	0.00	0.00
3	0.9791	1.0631	0.9977	0.8520	0.7215	0.00	0.00	0.00	0.00	0.00
4	0.5068	0.5772	0.4192	0.3214	0.5621	0.00	0.00	0.01	0.02	0.00
Big	0.2749	0.2112	0.2935	0.1696	0.0376	0.02	0.02	0.00	0.05	0.75
	H					p value				
Small	0.7516	0.2431	0.5786	0.2805	0.1216	0.00	0.27	0.02	0.21	0.61
2	0.5094	0.4022	0.1496	0.5335	0.1633	0.05	0.07	0.53	0.03	0.51
3	0.5115	0.4309	0.2244	0.5550	0.7781	0.03	0.07	0.34	0.02	0.00
4	0.5143	0.3035	0.5475	0.5623	0.2493	0.04	0.19	0.03	0.02	0.36
Big	-0.0198	0.0993	-0.0825	0.1603	0.2906	0.53	0.53	0.58	0.28	0.15
	P					p value				
Small	0.4201	-0.2542	-0.3870	-0.6147	-0.9220	0.09	0.25	0.11	0.01	0.00
2	0.5627	0.3385	0.0780	-0.4640	-0.9603	0.03	0.13	0.74	0.06	0.00
3	0.2037	0.1409	-0.2915	-0.3836	-0.7024	0.39	0.56	0.21	0.11	0.00
4	0.1566	-0.1471	0.0404	-0.3857	-0.7775	0.53	0.53	0.87	0.10	0.01
Big	0.1245	0.1687	-0.1514	-0.2419	-0.8221	0.28	0.28	0.31	0.10	0.00
	I					p value				
Small	0.7464	0.4070	0.5938	0.7164	-0.1134	0.02	0.15	0.06	0.01	0.71
2	0.3730	0.4600	0.2398	0.8869	0.7039	0.25	0.11	0.43	0.01	0.03
3	0.8747	0.8830	0.8886	0.9291	0.6508	0.00	0.00	0.00	0.00	0.03
4	0.6497	0.7208	0.8382	0.5774	0.4249	0.04	0.02	0.01	0.05	0.22
Big	-0.1528	0.2423	0.2922	0.4010	0.5341	0.23	0.23	0.13	0.03	0.04
	T					p value				
Small	-0.3085	-0.3531	-0.1327	0.0671	-0.0192	0.05	0.01	0.37	0.62	0.89
2	-0.5432	-0.6790	-0.5896	-0.7553	-0.4703	0.00	0.00	0.00	0.00	0.00
3	-0.5757	-0.7016	-0.7115	-0.5906	-0.5665	0.00	0.00	0.00	0.00	0.00
4	-0.4659	-0.4732	-0.4383	-0.3927	-0.7787	0.00	0.00	0.01	0.01	0.00
Big	0.0995	-0.0546	-0.2758	-0.2773	-0.6169	0.57	0.57	0.00	0.00	0.00

Source: Author's calculation

Panel C Size-Investment portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	0.4465	-0.2693	-0.9571	-1.1033	-0.8748	0.25	0.57	0.03	0.01	0.06
2	-0.5674	-0.0807	0.0446	0.1218	-0.1423	0.21	0.86	0.93	0.78	0.79
3	-0.8373	-0.2318	0.1359	-0.2647	0.2232	0.07	0.57	0.77	0.57	0.62
4	-0.3998	-0.0329	-0.5456	-0.4061	0.1639	0.38	0.95	0.25	0.34	0.73
Big	-0.3982	-0.6327	-0.2632	-0.4559	-0.2779	0.31	0.04	0.39	0.12	0.40
	Beta					p value				
Small	0.8693	0.9281	0.9092	0.9291	0.9185	0.00	0.00	0.00	0.00	0.00
2	1.0349	1.0687	1.0601	1.0521	1.0605	0.00	0.00	0.00	0.00	0.00
3	1.0255	1.0309	1.0727	1.0877	1.1026	0.00	0.00	0.00	0.00	0.00
4	1.0679	1.0825	0.9675	0.9867	1.0809	0.00	0.00	0.00	0.00	0.00
Big	1.0111	0.9162	0.9327	0.9133	0.9800	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	1.4627	1.6200	1.7994	1.6934	1.6813	0.00	0.00	0.00	0.00	0.00
2	1.3485	1.3852	1.2753	1.2228	1.2506	0.00	0.00	0.00	0.00	0.00
3	1.1035	0.9450	0.9229	0.8250	0.8186	0.00	0.00	0.00	0.00	0.00
4	0.5977	0.4403	0.3383	0.5100	0.5021	0.00	0.01	0.02	0.00	0.00
Big	0.2304	0.2747	0.1771	0.2245	0.1047	0.05	0.00	0.05	0.01	0.28
	H					p value				
Small	0.6632	0.4104	0.5026	0.3482	0.0418	0.00	0.09	0.03	0.10	0.86
2	0.4297	0.3049	0.3855	0.2319	0.4087	0.06	0.20	0.12	0.30	0.13
3	0.3865	0.4008	0.3872	0.8179	0.5021	0.10	0.06	0.10	0.00	0.03
4	0.5071	0.2978	0.6650	0.3632	0.3391	0.03	0.28	0.01	0.09	0.17
Big	0.0340	-0.0385	0.0156	0.0891	0.3098	0.86	0.80	0.92	0.55	0.06
	P					p value				
Small	-0.6399	-0.2254	-0.2843	-0.2277	-0.3680	0.00	0.35	0.21	0.28	0.12
2	0.1275	-0.0783	-0.0547	-0.1839	-0.2412	0.58	0.74	0.82	0.41	0.36
3	-0.3358	-0.1084	-0.1302	-0.0582	-0.4026	0.15	0.60	0.58	0.81	0.08
4	-0.1581	-0.3489	-0.1798	-0.0049	-0.4199	0.50	0.20	0.46	0.98	0.09
Big	-0.2872	-0.0564	-0.2347	-0.1310	-0.1577	0.15	0.72	0.13	0.38	0.34
	I					p value				
Small	1.6893	0.3906	0.7245	-0.0389	-0.4293	0.00	0.21	0.01	0.89	0.16
2	0.6092	0.9113	0.6595	0.1635	0.3222	0.04	0.00	0.04	0.57	0.34
3	1.6269	1.0185	0.7418	0.5522	0.2895	0.00	0.00	0.01	0.07	0.33
4	1.0798	1.0452	0.8750	0.0919	0.1144	0.00	0.00	0.01	0.74	0.71
Big	0.6708	0.3338	0.2825	0.1604	0.0669	0.01	0.10	0.16	0.40	0.75
	T					p value				
Small	-0.1694	-0.2357	-0.0625	-0.1673	-0.1097	0.16	0.11	0.65	0.20	0.45
2	-0.6245	-0.6215	-0.6359	-0.5913	-0.5683	0.00	0.00	0.00	0.00	0.00
3	-0.7126	-0.6269	-0.6525	-0.6234	-0.5308	0.00	0.00	0.00	0.00	0.00
4	-0.4229	-0.4518	-0.5395	-0.5852	-0.5439	0.00	0.01	0.00	0.00	0.00
Big	-0.2452	-0.1835	-0.2041	-0.4128	-0.2904	0.04	0.06	0.03	0.00	0.01

Source: Author's calculation

Panel D Size-Turnover portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-1.1717	0.2064	-0.1752	-0.8787	-0.7381	0.02	0.64	0.65	0.06	0.07
2	-0.2889	-0.0198	0.2056	-0.2659	-0.2733	0.53	0.97	0.69	0.59	0.56
3	-0.6379	0.2780	-0.3705	-0.0324	-0.2330	0.16	0.58	0.42	0.95	0.63
4	-0.7483	0.1689	-0.1432	-0.3337	-0.1685	0.13	0.72	0.78	0.49	0.69
Big	-0.1301	-0.4532	-0.3942	-0.5207	-0.5321	0.73	0.12	0.20	0.09	0.16
	Beta					p value				
Small	0.8643	0.9505	0.9872	0.9171	0.8353	0.00	0.00	0.00	0.00	0.00
2	1.0771	1.0185	1.1170	1.0044	1.0565	0.00	0.00	0.00	0.00	0.00
3	1.0720	1.0922	1.0465	1.0665	1.0401	0.00	0.00	0.00	0.00	0.00
4	0.9971	1.0487	1.0273	1.0429	1.0693	0.00	0.00	0.00	0.00	0.00
Big	0.9733	0.9149	0.9761	0.9312	0.9576	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	1.2622	1.8777	1.7407	1.6022	1.7834	0.00	0.00	0.00	0.00	0.00
2	1.2992	1.1688	1.4180	1.2989	1.2976	0.00	0.00	0.00	0.00	0.00
3	0.7872	1.0703	0.9412	0.8341	0.9818	0.00	0.00	0.00	0.00	0.00
4	0.5301	0.5221	0.4165	0.4171	0.5047	0.00	0.00	0.01	0.00	0.00
Big	0.2177	0.2573	0.1030	0.1787	0.2515	0.05	0.00	0.26	0.05	0.03
	H					p value				
Small	0.8286	0.1073	0.5954	0.5158	-0.0937	0.00	0.63	0.00	0.03	0.65
2	0.2902	0.4775	0.1113	0.5429	0.3443	0.21	0.04	0.67	0.03	0.15
3	0.7583	0.1370	0.3184	0.7533	0.5285	0.00	0.59	0.18	0.00	0.04
4	0.1856	0.3318	0.4941	0.6145	0.5514	0.46	0.16	0.06	0.01	0.01
Big	-0.0093	-0.1182	0.2360	0.1265	0.1753	0.96	0.42	0.13	0.41	0.36
	P					p value				
Small	-0.1776	-0.6748	-0.2998	-0.1135	-0.4816	0.49	0.00	0.13	0.63	0.02
2	0.0222	-0.1315	-0.1664	-0.0069	-0.1454	0.92	0.57	0.53	0.98	0.54
3	-0.0093	-0.3492	-0.1924	-0.3444	-0.1292	0.97	0.17	0.41	0.16	0.60
4	-0.2744	-0.2785	-0.1819	-0.0293	-0.3398	0.27	0.24	0.48	0.90	0.12
Big	-0.3301	-0.0969	-0.0509	-0.1345	-0.2587	0.08	0.51	0.74	0.38	0.18
	I					p value				
Small	0.0143	1.1144	0.3340	0.1899	0.7096	0.97	0.00	0.18	0.53	0.01
2	0.2297	0.6217	0.4572	0.6780	0.6845	0.44	0.04	0.18	0.03	0.03
3	0.8600	0.6874	0.7426	1.0459	0.9009	0.00	0.04	0.01	0.00	0.01
4	0.6264	0.6879	0.8487	0.4864	0.5626	0.05	0.02	0.01	0.12	0.04
Big	0.5955	0.1938	0.2694	0.3322	0.1236	0.01	0.30	0.17	0.10	0.61
	T					p value				
Small	0.7178	0.0607	-0.2083	-0.5194	-0.7963	0.00	0.66	0.08	0.00	0.00
2	-0.1445	-0.4669	-0.5886	-0.8926	-0.9501	0.31	0.00	0.00	0.00	0.00
3	-0.0117	-0.4656	-0.5959	-0.9847	-1.0967	0.93	0.00	0.00	0.00	0.00
4	0.6264	-0.2877	-0.4785	-0.6945	-0.8791	0.17	0.05	0.00	0.00	0.00
Big	0.1301	-0.0658	-0.1028	-0.3736	-0.9187	0.26	0.46	0.28	0.00	0.00

Source: Authors' Calculation

Table:5 Regression Coefficients of Six Factor Model on 25 Korean portfolios

Panel A Size-value portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-0.5166	-0.6691	-0.1598	-0.2950	-0.9779	0.23	0.09	0.75	0.52	0.03
2	-0.8289	-0.8256	-1.2709	-0.8277	-1.2025	0.05	0.04	0.01	0.06	0.01
3	-0.7654	-1.2712	-1.0140	-1.3584	-1.0950	0.07	0.00	0.02	0.00	0.02
4	-0.9464	-1.1271	-0.8954	-0.6909	-0.5506	0.03	0.01	0.07	0.13	0.29
Big	-0.6509	-0.3822	-0.5926	-0.6947	-0.9222	0.14	0.28	0.06	0.07	0.01
	Beta					p value				
Small	0.8442	0.8122	0.7511	0.8153	0.7677	0.00	0.00	0.00	0.00	0.00
2	0.7169	0.8539	0.8047	0.8556	0.8061	0.00	0.00	0.00	0.00	0.00
3	0.7818	0.8157	0.7953	0.7805	0.7529	0.00	0.00	0.00	0.00	0.00
4	0.8245	0.7591	0.7823	0.8013	0.7795	0.00	0.00	0.00	0.00	0.00
Big	0.9063	0.8776	0.8040	0.8004	0.8928	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	1.0774	0.8128	1.0695	1.0223	1.3012	0.00	0.00	0.00	0.00	0.00
2	0.4919	0.5897	0.6626	0.7448	0.8637	0.00	0.00	0.00	0.00	0.00
3	0.0667	0.3367	0.2059	0.1961	0.2152	0.69	0.05	0.24	0.28	0.24
4	-0.1963	-0.3526	-0.2799	-0.3953	-0.3172	0.24	0.03	0.16	0.03	0.13
Big	-0.3633	-0.3168	-0.1247	-0.3212	-0.3322	0.04	0.03	0.32	0.04	0.03
	H					p value				
Small	0.7413	0.7566	0.7058	0.2398	-0.1419	0.00	0.00	0.00	0.28	0.51
2	0.9726	0.5875	0.6148	0.3782	-0.2725	0.00	0.00	0.01	0.07	0.18
3	0.9935	0.6692	0.6940	0.5705	-0.0085	0.00	0.00	0.00	0.01	0.97
4	1.0712	0.7758	0.5167	0.0960	-0.0513	0.00	0.00	0.03	0.66	0.83
Big	0.9560	0.7885	0.4296	-0.1076	-0.3832	0.00	0.00	0.00	0.55	0.03
	P					p value				
Small	-0.3659	-0.6956	-0.7550	-0.6674	-0.5336	0.08	0.00	0.00	0.00	0.02
2	-0.6176	-0.3517	-0.4798	-0.7021	-0.4658	0.00	0.07	0.03	0.00	0.03
3	-0.6253	-0.3413	-0.7517	-0.5890	-0.6960	0.00	0.09	0.00	0.01	0.00
4	-0.6499	-0.8018	-0.3917	-0.6062	-0.5899	0.00	0.00	0.10	0.01	0.02
Big	-0.6560	-0.7078	-0.4395	-0.2579	-0.2777	0.00	0.00	0.00	0.16	0.12
	I					p value				
Small	0.1131	0.5927	0.6307	0.3372	0.2733	0.68	0.02	0.05	0.25	0.35
2	0.5198	0.2315	0.2917	0.1458	0.2090	0.05	0.35	0.32	0.60	0.44
3	0.2612	0.0635	0.3699	0.4005	0.5369	0.32	0.81	0.19	0.17	0.06
4	0.3676	0.3405	0.2446	0.3689	0.3325	0.17	0.18	0.43	0.21	0.31
Big	0.2955	0.3012	0.2336	0.2761	0.5752	0.29	0.18	0.23	0.26	0.02
	T					p value				
Small	-0.5725	-0.6209	-0.9517	-0.8136	-0.5481	0.01	0.00	0.00	0.00	0.01
2	-0.8770	-0.7651	-0.9465	-0.6375	-0.5557	0.00	0.00	0.00	0.00	0.01
3	-0.8004	-0.8325	-0.9132	-0.9612	-0.7222	0.00	0.00	0.00	0.00	0.00
4	-0.8395	-0.8335	-0.8484	-0.6908	-0.8457	0.00	0.00	0.00	0.00	0.00
Big	-0.7048	-0.6477	-0.5764	-0.4709	-0.3705	0.00	0.00	0.00	0.01	0.04

Source: Author's calculation

Panel B Size-Profitability portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-0.0295	-0.5724	0.0509	-0.6463	-1.0299	0.95	0.31	0.90	0.10	0.02
2	-1.3068	-0.7298	-1.0113	-1.0227	-0.8677	0.00	0.10	0.03	0.03	0.05
3	-0.8727	-0.9523	-1.0808	-1.0374	-1.6092	0.05	0.02	0.01	0.01	0.00
4	-0.8730	-1.0168	-1.1159	-0.6013	-0.5899	0.05	0.02	0.01	0.21	0.27
Big	-1.1771	-0.6482	-0.6330	-0.4988	-0.3081	0.00	0.08	0.08	0.20	0.45
	Beta					p value				
Small	0.8055	0.7997	0.8269	0.7263	0.8498	0.00	0.00	0.00	0.00	0.00
2	0.7372	0.8250	0.8046	0.8393	0.8308	0.00	0.00	0.00	0.00	0.00
3	0.8159	0.7636	0.7678	0.7859	0.7901	0.00	0.00	0.00	0.00	0.00
4	0.7718	0.8343	0.7639	0.7875	0.7858	0.00	0.00	0.00	0.00	0.00
Big	0.8667	0.8265	0.7936	0.8863	0.8942	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	0.8928	1.2411	1.1025	1.1020	1.1079	0.00	0.00	0.00	0.00	0.00
2	0.5553	0.3997	0.6119	0.7108	1.0823	0.00	0.02	0.00	0.00	0.00
3	0.2339	0.2574	0.1867	0.3301	0.0204	0.19	0.10	0.26	0.04	0.91
4	-0.0857	-0.2333	-0.1453	-0.4735	-0.6031	0.63	0.16	0.37	0.02	0.01
Big	-0.1643	-0.2530	-0.2369	-0.3717	-0.4112	0.29	0.09	0.10	0.02	0.01
	H					p value				
Small	0.4779	0.7663	0.3145	0.4656	0.0292	0.02	0.00	0.09	0.01	0.89
2	0.7125	0.5232	0.5109	0.6774	-0.1427	0.00	0.01	0.02	0.00	0.50
3	0.5534	0.6499	0.6226	0.3786	0.6606	0.01	0.00	0.00	0.05	0.00
4	0.4524	0.3342	0.3193	0.5759	0.7295	0.04	0.09	0.10	0.01	0.00
Big	0.0164	0.1747	0.2804	0.5106	0.7308	0.93	0.32	0.10	0.01	0.00
	P					p value				
Small	-0.0165	-0.3087	-0.5477	-1.0450	-1.1274	0.94	0.25	0.00	0.00	0.00
2	-0.1711	-0.3675	-0.3389	-0.6594	-1.0731	0.37	0.08	0.12	0.00	0.00
3	-0.0287	-0.3498	-0.4825	-0.8359	-1.2844	0.89	0.07	0.02	0.00	0.00
4	0.0092	-0.3289	-0.3995	-0.7467	-1.5622	0.97	0.10	0.04	0.00	0.00
Big	-0.1958	-0.3143	-0.4407	-0.5922	-0.7881	0.29	0.08	0.01	0.00	0.00
	I					p value				
Small	0.2554	0.3603	0.2535	0.6234	0.4341	0.35	0.31	0.31	0.01	0.13
2	0.3873	0.2496	0.3344	0.3668	0.0622	0.12	0.37	0.25	0.20	0.82
3	0.3192	0.3093	0.1755	0.3513	0.4704	0.26	0.22	0.50	0.17	0.10
4	0.2297	0.5125	0.1745	0.1371	0.5668	0.42	0.05	0.50	0.65	0.10
Big	0.6036	0.3683	0.2308	0.4511	-0.0196	0.01	0.12	0.31	0.07	0.94
	T					p value				
Small	-0.7619	-0.9701	-0.5643	-0.6209	-0.3521	0.00	0.00	0.00	0.00	0.11
2	-0.9686	-0.6519	-0.7987	-0.9055	-0.4497	0.00	0.00	0.00	0.00	0.04
3	-0.8107	-0.7553	-0.8484	-0.6076	-1.2030	0.00	0.00	0.00	0.00	0.00
4	-0.9908	-0.6838	-0.5164	-0.7505	-1.1200	0.00	0.00	0.01	0.00	0.00
Big	-0.5091	-0.4607	-0.4609	-0.5519	-0.8116	0.01	0.01	0.01	0.00	0.00

Source: Author's calculation

Panel C Size-Investment Portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-0.7679	-0.2639	0.0509	-1.0838	-0.5759	0.10	0.55	0.90	0.01	0.22
2	-0.8259	-0.9149	-0.8674	-0.9553	-1.3714	0.04	0.04	0.03	0.04	0.00
3	-0.8198	-1.0675	-0.9356	-1.3829	-1.3412	0.05	0.02	0.03	0.00	0.00
4	-0.9627	-0.8930	-0.7899	-1.0010	-0.5464	0.07	0.06	0.06	0.02	0.23
Big	-1.1044	-0.6289	-0.7000	-0.6777	-0.1293	0.01	0.07	0.03	0.08	0.74
	Beta					p value				
Small	0.7131	0.7798	0.8269	0.7835	0.8843	0.00	0.00	0.00	0.00	0.00
2	0.7767	0.8271	0.7726	0.8623	0.7947	0.00	0.00	0.00	0.00	0.00
3	0.8415	0.7799	0.7940	0.7123	0.7633	0.00	0.00	0.00	0.00	0.00
4	0.8366	0.8043	0.7499	0.7626	0.7898	0.00	0.00	0.00	0.00	0.00
Big	0.8438	0.8038	0.8297	0.8841	0.9047	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	0.9904	1.0139	1.1025	1.0772	1.0748	0.00	0.00	0.00	0.00	0.00
2	0.5875	0.8662	0.5533	0.6473	0.6787	0.00	0.00	0.00	0.00	0.00
3	-0.0201	0.4820	0.2192	0.2138	0.1316	0.90	0.01	0.21	0.20	0.44
4	-0.2979	-0.3564	-0.2558	-0.2547	-0.3988	0.16	0.06	0.12	0.14	0.03
Big	-0.2239	-0.2318	-0.2729	-0.2525	-0.4726	0.16	0.10	0.04	0.11	0.00
	H					p value				
Small	0.6101	0.6612	0.3145	0.6496	0.0687	0.01	0.00	0.09	0.00	0.76
2	0.5471	0.4933	0.3865	0.3883	0.4782	0.00	0.02	0.04	0.08	0.03
3	0.7173	0.4212	0.6005	0.5439	0.5993	0.00	0.05	0.00	0.01	0.00
4	0.6237	0.3538	0.2581	0.5523	0.6321	0.01	0.11	0.19	0.01	0.00
Big	0.1950	0.1319	0.2854	0.6097	0.4955	0.29	0.42	0.06	0.00	0.01
	P					p value				
Small	-0.6881	-0.6453	-0.5477	-0.4884	-0.6455	0.00	0.00	0.00	0.02	0.01
2	-0.8763	-0.3978	-0.4583	-0.3554	-0.5079	0.00	0.06	0.02	0.12	0.02
3	-0.5830	-0.5743	-0.6442	-0.4651	-0.7243	0.00	0.01	0.00	0.02	0.00
4	-0.7137	-0.6169	-0.4284	-0.6660	-0.6151	0.01	0.01	0.03	0.00	0.01
Big	-0.2719	-0.3928	-0.3339	0.5799	-0.7681	0.15	0.02	0.03	0.00	0.00
	I					p value				
Small	0.8864	0.5777	0.2535	0.2458	-0.0253	0.00	0.04	0.31	0.37	0.93
2	1.0289	0.5486	0.1744	0.0144	-0.3814	0.00	0.05	0.48	0.96	0.18
3	0.8011	0.4001	0.2048	0.1989	0.0260	0.00	0.17	0.46	0.45	0.92
4	1.0336	0.7722	0.0579	0.1013	-0.3451	0.00	0.01	0.82	0.71	0.24
Big	0.9464	0.2817	0.2487	0.3353	-0.1794	0.00	0.20	0.21	0.18	0.47
	T					p value				
Small	-0.8779	-0.9333	-0.5643	-0.8205	-0.3148	0.00	0.00	0.00	0.00	0.17
2	-0.8379	-0.6505	-0.7173	-0.6593	-0.9342	0.00	0.00	0.00	0.00	0.00
3	-1.0030	-0.7273	-0.6411	-0.8476	-1.0259	0.00	0.00	0.00	0.00	0.00
4	-0.9526	-0.6329	-0.6956	-0.7692	-1.0190	0.00	0.01	0.00	0.00	0.00
Big	-0.6025	-0.3743	-0.4997	-0.6016	-0.7327	0.00	0.03	0.00	0.00	0.00

Source: Author's calculation

Panel D Size-Turnover portfolios										
	1	2	3	4	5	1	2	3	4	5
Six Factor Model	Alpha					p value				
Small	-0.5529	-0.3224	-0.3878	-0.4996	-0.8780	0.21	0.43	0.36	0.25	0.10
2	-1.0782	-0.8516	-0.9903	-1.0594	-0.9763	0.01	0.06	0.02	0.02	0.03
3	-0.8716	-0.9971	-0.8277	-1.2459	-1.6307	0.02	0.02	0.08	0.01	0.00
4	-1.2351	-0.8095	-0.9998	-0.5069	-0.6193	0.01	0.08	0.04	0.31	0.12
Big	-0.9455	-0.5524	-0.4821	-0.5348	-0.7181	0.01	0.09	0.19	0.15	0.06
	Beta					p value				
Small	0.8075	0.8615	0.8286	0.8327	0.6524	0.00	0.00	0.00	0.00	0.00
2	0.7259	0.8366	0.7879	0.8525	0.8353	0.00	0.00	0.00	0.00	0.00
3	0.6822	0.8346	0.8401	0.8204	0.7417	0.00	0.00	0.00	0.00	0.00
4	0.7730	0.8083	0.8133	0.7649	0.7858	0.00	0.00	0.00	0.00	0.00
Big	0.7928	0.9016	0.8037	0.8830	0.8936	0.00	0.00	0.00	0.00	0.00
	S					p value				
Small	0.8615	1.1126	0.9939	1.2251	1.0864	0.00	0.00	0.00	0.00	0.00
2	0.4648	0.6102	0.7300	0.7597	0.7873	0.00	0.00	0.00	0.00	0.00
3	0.0448	0.1841	0.3344	0.2891	0.1784	0.76	0.27	0.08	0.13	0.30
4	-0.1000	-0.1079	-0.2942	-0.4111	-0.6422	0.57	0.56	0.12	0.04	0.00
Big	-0.1011	-0.2262	-0.2605	-0.2807	-0.5885	0.45	0.09	0.08	0.06	0.00
	H					p value				
Small	0.1304	0.3677	0.4114	0.6611	0.7401	0.53	0.06	0.04	0.00	0.00
2	0.4092	0.6823	0.6961	0.4342	0.0631	0.03	0.00	0.00	0.04	0.77
3	0.4315	0.6269	0.5684	0.6964	0.5565	0.01	0.00	0.01	0.00	0.01
4	0.4118	0.5674	0.5903	0.5782	0.2541	0.05	0.01	0.01	0.02	0.18
Big	0.3169	0.3846	0.6309	0.1751	0.1787	0.05	0.01	0.00	0.32	0.32
	P					p value				
Small	-0.6789	-0.5026	-0.6575	-0.7757	-0.3978	0.00	0.01	0.00	0.00	0.12
2	-0.4951	-0.6673	-0.4283	-0.5637	-0.4475	0.01	0.00	0.04	0.01	0.04
3	-0.5228	-0.7353	-0.4491	-0.6268	-0.6622	0.00	0.00	0.05	0.01	0.00
4	-0.4912	-0.6415	-0.4427	-0.8794	-0.5865	0.02	0.00	0.05	0.00	0.00
Big	-0.2925	-0.6348	-0.7314	-0.2815	-0.4002	0.07	0.00	0.00	0.12	0.03
	I					p value				
Small	0.2837	0.6338	0.0717	0.6594	0.2929	0.31	0.02	0.79	0.02	0.38
2	0.3528	0.4214	0.3743	0.4609	-0.2125	0.15	0.15	0.17	0.10	0.46
3	0.1330	0.4609	0.2784	0.4249	0.3410	0.57	0.08	0.36	0.16	0.21
4	0.2309	0.1290	0.2962	0.6912	0.2859	0.41	0.66	0.32	0.03	0.26
Big	0.0333	0.4266	0.5261	0.2165	0.4445	0.88	0.04	0.02	0.36	0.07
	T					p value				
Small	-0.0612	-0.3515	-0.5405	-0.8811	-1.6801	0.77	0.08	0.01	0.00	0.00
2	-0.1354	-0.6171	-1.0060	-0.8596	-1.1621	0.47	0.01	0.00	0.00	0.00
3	-0.2162	-0.5447	-0.8631	-1.0651	-1.5387	0.22	0.01	0.00	0.00	0.00
4	-0.1950	-0.5149	-0.8607	-1.0503	-1.4221	0.36	0.02	0.00	0.00	0.00
Big	-0.2243	-0.2805	-0.5801	-0.6914	-1.0024	0.17	0.07	0.00	0.00	0.00

Source: Author's calculation

Table: 6 Comparative analysis of Asset Pricing models using average Adjusted R²

Model	India	Korea
Fama-French Three Factor Model	Adj. R ² = 70.57%	Adj. R ² = 68.57
Fama-French Five Factor Model	Adj. R ² = 77.23%	Adj. R ² = 70.32%
Six Factor Model	Adj. R ² = 83.58%	Adj. R ² = 74.61%

Source: Authors' calculation

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The Impact of Environmental, Social, and Governance (ESG) Reporting on Corporate Value: An Empirical Evidence from India

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Abstract

Environmental, Social, and Governance (ESG) reporting have emerged as critical determinants of corporate value and investor decision-making in recent years. As global challenges such as climate change, social inequality, and governance failures have come into sharper focus, stakeholders around the world increasingly demand greater transparency and accountability from corporations. As we know that, India is a rapidly growing economy characterized by evolving regulatory frameworks and diverse socio-economic challenges, therefore, this study investigates the impact of ESG disclosures on corporate value, with a specific focus on firms operating in India. The study uses 255 sample companies listed in Bombay Stock Exchange (BSE-500 Index) from 2019 to 2023. The overall and individual environment, social, and governance (ESG) disclosure scores taken as a proxy to measure the effect of ESG disclosure on corporate value. For the purpose of ESG disclosure score, self- developed framework is used. Further, this study considers the return on assets (ROA), return on equity (ROE), return on capital employed (ROCE), Tobin's Q, Price Earnings ratio (P/E ratio), and Price to Book value ratio (P/B ratio) as corporate value measures. In this study, panel data regression analysis is used to examine the influence of ESG disclosures on corporate value of the firm. The study results show a positive relationship between ESG disclosure and firm performance. It suggests that companies' desire to enhance their performance need to pay more attention towards sustainability and ESG disclosures. The findings underscore the critical role of regulatory initiatives in shaping corporate ESG practices. This study confirms that ESG disclosures are not merely a regulatory requirement but a critical determinant of corporate value in the Indian market. By fostering greater transparency and accountability, ESG practices enhance firm resilience and attractiveness to stakeholders. As sustainability becomes a central tenet of business strategy, companies that proactively embrace ESG principles are likely to sustain long-term value creation in an increasingly conscientious market landscape.

Keywords: ESG, Corporate Value, Sustainability, ESG Disclosure, ESG Reporting, Sustainability Reporting

Introduction

The rising significance of Environmental, Social, and Governance (ESG) disclosure in corporate reporting reflects a broader shift towards sustainable and ethical business practices. Due to the modern concept of sustainability, the markets have grown more competitive and dynamic, which has created tremendous pressure on corporations to achieve long-term sustainability and profitability (Malik and Kashiramka, 2024). ESG reporting practices focus on transforming corporations into accountable entities that take social and environmental issues seriously through which long-term sustainability can be achieved (Alshehhi *et al.*, 2018). Therefore, Environmental, Social, and Governance (ESG) is critical to businesses and the expansion of the economy as a whole. These factors are being given weightage in any informed investment decision by all types of investors (Maji and Lohia, 2023). Because of the significant effect of these nonfinancial factors on future cash flows of a business, they are considered equally important on par with financial information. Regulatory frameworks across the globe have also begun to promote and regulate the disclosure of ESG information either in annual reports or as separate reports. These ESG issues also have a significant bearing on the financial and market performance of companies. Therefore, it is important to identify the influence of these ESG disclosures on corporate value. To fill this research gap, this study is conducted to examine the impact of ESG reporting disclosures on the value of corporations.

The review of literature highlighted that a number of studies have been conducted on examining the association between ESG reporting and firm performance (Hamrouni *et al.*, 2019; Alareeni and Hamdan, 2020; Ademi and Klungseth, 2022) in a country where ESG reporting is mandatory. Similarly, the literature also highlighted studies in the Indian context (Maji and Lohia, 2023; Rao *et al.*, 2023; Malik and Kashiramka, 2024), conducted based on the scores taken from ESG credit rating agencies and traditional measures of performance. However, this study differs from and extends previous literature in two ways. First, the study analyses the extent of ESG reporting practices of sample companies through self- developed ESG framework particularly for Indian

companies. Second, it investigates the influence of ESG disclosures and corporate value using ESG scores collected from a self-developed ESG framework. Therefore, this study provides a comprehensive view of ESG disclosure and corporate value.

Research Objectives

The study has the following objectives:

- To Examine the Extent of ESG Reporting practices of the selected companies in India.
- To Analyse the Impact of ESG Reporting on corporate value.
- To Provide Recommendations for Enhancing ESG Reporting Practices.

Review of Literature

In this section, previous literature related to the various theories studied and used to develop the conceptual framework and research questions for the study. There are various theories related to sustainability and ESG reporting. However, the most relevant theories are stakeholder and legitimacy theory. The stakeholder theory has a root cause for developing sustainability reporting and ESG disclosure (Freeman, 1984; Velte, 2017). As sustainability decision-making is closely linked to stakeholders' demands, the ESG reporting idea is also linked to stakeholder theory, which emphasises that companies are expected to meet the needs of stakeholders both primary as well as secondary to the firm (Freeman and McVea, 2001). Freeman (1984) defines the stakeholder as internal and external: workers, customers, suppliers, local community and organization. The stakeholder theory aims to maximizing the shareholder's wealth, winning the shareholders trust, and reducing managerial cost. Gray *et al.* (1995) employed stakeholder theory and states that as the stakeholder is more important to the organisation, the more effort should be made to maintain good relationship with them. As a result, businesses frequently employ information to manage or manipulate stakeholders in order to gain their support for organisational survival, as well as a strategic marketing strategy to promote a positive image among their constituents. The other prior studies who employed stakeholder theory to examine the impact of ESG reporting on firm performance includes Phillips (2003) and Tamimi and Sebastianelli (2017). Legitimacy theory states that there is an apparent contract between company and society which requires company to fulfil their societal obligations and follow societal norms to ensure their survival (Burhan and Rahmanti, 2012). Similarly, Deegan (2002) states that the society allows corporations to own and use natural resources and to hire employees. Therefore, the organizations have the permission to operate from society and is ultimately accountable to society for how it operates and what it does. If society feels that an organisation has broken its share of the social contract, the organization's survival will be jeopardised. As a result, legitimacy is regarded as a strategic resource on which an organization's sustainability is predicated (Dowling and Pfeffer, 1975). Legitimacy theory is also frequently used by social and environmental academics to explain why corporate management takes certain measures, such as revealing specific social and environmental facts as part of its economic strategy. For example, (Lindblom, 1994; Deegan, 2002; Patten, 2005) employed legitimacy theory as the theoretical framework for environmental and social reporting. It indicates that legitimacy theory is a positive theory that aims to explain or forecast specific managerial activities. The literature also highlighted other theories i.e., signalling theory, resource-dependency theory and social contract theory in relation to sustainability of an organization. However, the two most prominent theory for ESG reporting are legitimacy and stakeholders' theory. As a result, this study will use the legitimacy as well as stakeholder theory to examine the motivation for ESG reporting in India.

ESG Disclosure and Firm Performance

There are number of studies who have analysed the relationship between ESG disclosure and firm performance. Balatbat and Carmicheal (2012) analysed impact of ESG (environmental, social and governance) practices on the financial performance of companies listed in Australian Securities Exchange for the period of 2008-2010. They found positive relationship between ESG scores and firm performance. In the international context, the other studies (Atan *et al.*, 2016; Tarumji *et al.*, 2016; Fatemi *et al.*, 2017; Bodhanwala and Bodhanwala, 2018; Yu *et al.*, 2018; Albitar *et al.*, 2019; Triyani *et al.*, 2020) also found positive relation of ESG scores with firm value and performance. In Indian context, studies (Chelwat and Trivedi, 2016; Dalal and Thaker, 2019) examined the influence of ESG factors on the performance of Indian public limited companies in terms of profitability and the value of the firm. They found that good corporate ESG performance enhances financial performance through both accounting as well as market-based measures.

The literature also highlighted number of studies showing no impact of ESG reporting on corporate value. For example, Farooq (2015) examined impact of ESG disclosures on firm performance of emerging markets. They found that there was no significant impact of ESG scores on firm profitability as well as shareholder's wealth. Farooq (2015) also suggested that the ESG information is not valued by stock market participants in the

emerging markets. There are other studies as well, such as (Atan *et al.*, 2017; Junius *et al.*, 2020) evidencing no significant impact of ESG reporting on corporate value.

The number of literatures also shows mixed results related to ESG reporting and corporate value. For example; Velte (2017) examined the impact of ESG performance on the corporate value of German companies for the year 2010-2014. They have used two measures for corporate value i.e., ROA and Tobin's Q. He found that ESG performance had positive impact on ROA but no impact on Tobin's Q. Therefore, the author found a mixed result. He also showed that governance had the strongest impact on firm value as compared to environmental and social component of ESG performance. The other important evidence was provided by Buallay (2019) who made a comparison between manufacturing and banking sectors in relation to the level of ESG reporting and its impact on operational, financial and market performance. He showed that ESG positively affect the operational, financial and market performance in the manufacturing sector whereas negatively affect the operational, financial and market performance in the banking sector. In the Indian context as well, Fahad and Busru (2020) investigated the effect of ESG disclosure on both firm profitability and firm value among Indian companies. They have analysed 386 Indian firms for the period of 2007-2016. They found negative impact of ESG disclosure on firm profitability but positive impact on firm value. The other author which evidenced mixed results for different dimensions of ESG disclosures are (Bullay 2017; Yoon *et al.*, 2018; Sharma *et al.*, 2019; Alareeni and Hamdan,2020).

To summarise, it can be seen that the findings of the studies have been mixed, as evidenced by the preceding discussion. It also highlighted the mixed result which create confusion. Therefore, it highlighted a need to revisit the findings from time to time, and more research so that clearer view can be provided. Furthermore, the limitations of these studies reveal a research gap that must be addressed, particularly for S&P 500-listed companies. Therefore, this study is conducted to analysed the impact of ESG disclosure on corporate value.

Research Questions

On the basis of the review of literature, the study has two main research questions. These are as follows:

(RQ1): What is the current state of ESG reporting practices among Indian corporations?

(RQ2): What is the impact of ESG reporting on the financial performance and market valuation of companies in India?

Data and Methodology

The initial sample of the study includes all companies listed on the BSE 500 index as on March 31 2021. Review of literature indicated that there are certain types of companies, which are not apt for determining their ESG practices. Therefore, all the public sector companies, banking and financial companies and non- financial companies like communication and trade were deleted from the sample of BSE 500 companies. After that, the companies having different financial year and companies with missing data were also deleted. It all resulted in final sample of 255 companies over the period of 2019-2023.

ESG Disclosure Measures

In order to achieve the objective of the study, the study has used ESG scores of sample companies. For ESG scores, ESG framework has been developed for companies in India using different standardized framework i.e., GRI framework, Dow Jones ESG index, NASDAQ ESG Index, WEF stakeholder capitalism matrices, and national guidelines provided by SEBI. In order to collect ESG scores of sample companies, content analysis methodology is adopted. The content analysis of annual reports of the sample companies is conducted based on the developed ESG framework.

Construction of ESG Disclosure Index

A methodology has been adopted to develop ESG reporting index based on the research methodology and works of previous researcher (Garg, P., 2017; Aggarwal and Singh, 2018; Goel, P., 2018; Sharma *et al.*, 2020). The following criterion has been used for the construction of the ESGD Index:

- The Environment, Social, and Governance themes and items of the developed index is based on four international frameworks i.e., GRI framework, Dow Jones ESG index, NASDAQ ESG Index, WEF stakeholder capitalism matrices, and one Indian framework i.e., national guidelines provided by SEBI for the preparation of Business Responsibility & Sustainability Report (BRSR).
- To identify initial disclosure, a total of the disclosures of each selected indices and framework has been done.
- To select final disclosures out of those initial items, the content analysis of the selected standardized index was undertaken to delete same and repetitive items. It resulted in 135 items.

- After that, the index is tested for face validity. The face validity of the index was established after the modifications which were made on the basis of the advice received by experts in the area of ESG. The final index consists of 95 items.
- In order to identify the factors, exploratory factor analysis was conducted. A questionnaire was created using the ESG disclosure items to gather stakeholders' opinions on company ESG reporting. The factor analysis reduced the items to 90 items in developed ESG index.
- The constructed index has been checked for its reliability by calculating cronbach's alpha. The scale comprised of three factors constituting a total of 90 items. The reliability coefficient indicated that the instrument is quite reliable as the alpha coefficient is 0.923 (>0.60).

Coding of ESG Reporting Framework

To check the extent of ESG reporting made by the companies, a scoring methodology has been adopted from the previous literature (Kansal *et al.*, 2014; Garg, 2017; Sekhon and Kathuria, 2019). A disclosure is given a score of zero (0), if no information is being provided; one (1), if information is provided but neither qualitatively nor quantitatively, i.e., very general things are discussed about a particular disclosure; two (2), if information is being provided qualitatively only, i.e., how the company intends to complete the task for that particular disclosure; three (3), if the information is provided with monetary figures as well. This dimension is adopted as information on ESG is highly subjective, it cannot be actually measured in terms of 'yes' or 'no' only.

Corporate Value Measures

The study measures corporate value based on two dimensions: accounting and marketing-based measure. The indicators of accounting-based measure include ROA, ROE, and ROCE whereas, the marketing-based measures includes Tobin's Q, P/E Ratio, and P/B ratio. These variables are frequently used as dependent variables to measure the corporate value by employing suitable panel data regression models in prior studies (Chelawat and Trivedi; Velte, 2017; Bodhanwala and Bodhanwala 2018; Xie *et al.*, 2018; Buallay, 2019; Alareeni and Hamdan, 2020; Shaikh, 2021; Vellimuthu *et al.*, 2024). ROA is used as a measure for comparing the performance of a company relative to its total assets (Jha and Rangarajan, 2020). Return on equity indicates how well the company has utilized the shareholders' money in generating returns for them (Garg, 2015). Return on capital employed (ROCE) used for comparing performance between businesses as a company which earns higher returns per rupee of capital invested in business generates more value (Chelawat and Trivedi, 2016). Tobin's Q is defined as the ratio of the market value of the firm to the book value of total assets, where the market value is measured by the sum of the market value of equity and the book value of total liabilities (Gill and Kaur, 2015). Price Earnings ratio is another market value-based performance measure that signifies earning capacity of the firm by calculating the price per share divided by earnings per share (Kothari and Sloan, 1992; Kang *et al.*, 2010). Finally, Price to Book Value ratio (PBV) is defined as a comparison between the stock price (market value of shares) and the book value of shares (Brigham and Gapenski, 2006). The data related to the corporate value is collected from prowest database for the period 2019-2023.

Control Variables

In addition to the variables discussed above, a number of control variables is also included in the study. As the study aimed at determining whether there exists any relation between corporate value and ESG scores, it is imperative that other influencing aspect of ESG reporting and corporate value or both should be controlled. The control variable used in the study have been derived through a review of prior literature (Garg, 2015; Arayssi *et al.*, 2016; Chelawat and Trivedi, 2016; Velte, 2017; Yu *et al.*, 2017; Dalal and Thaker, 2019; Jha and Rangarajan, 2020). The literature indicates multiple number of control variables. However, the most used control variable in the similar kind of studies have been taken. In this study, to control for companies-specific characteristics size of the company, age of the company, leverage of the company, risk are taken as control variable. The data related to the control variable is collected from prowest database for the period 2019-2023.

Methodology

In order to examine the impact of ESG disclosure on the corporate value, the study has used panel regression analysis by employing six panel regression models. These panel regression models are as follows:

Model 1: $ROA_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Model 2: $ROE_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Model 3: $ROCE_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Model 4: $TOBINQ_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Model 5: $P/B_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Model 6: $P/E_{it} = \alpha_i + \beta_1 ESGDS_{it} + \beta_2 SIZE_{it} + \beta_3 AGE_{it} + \beta_4 LEV_{it} + \beta_5 RISK_{it} + \epsilon_{it}$

Where, α_i refers to intercept, β represents regression coefficients that capture the impact of ESGDS on corporate value, ROA_{it} denotes return on assets that refers to accounting based measure, ROE_{it} indicates the return on

equity referring to a financial-based measure, *Tobin's Q* represents market based performance measures, *PE_{it}* denotes price earnings ratio which refers to a market value-based measure, *SIZE_{it}* indicates the natural logarithm of total assets used as a proxy for firm size, *AGE_{it}* indicates the natural logarithm of the number of years since the company's inception used as proxy of firm age, *LEV_{it}* represents the debt-equity ratio which is used as a proxy for leverage, *RISK_{it}* is calculated as beta which represent the risk associated with different firm, *i* and *t* represent individual firms from 1 to 255 firms and the time period from 2017 to 2021, *eit* refers to the error term.

In order to check the influence of ESG disclosure on the corporate value, the study employs three panel regression models, pooled, random, and fixed effects models (Chelawat and Trivedi, 2016; Dalal and Thaker, 2019; Buallay, 2020; Hongming *et al.*, 2020; Vellimuthu *et al.*, 2024). The data used in the study is firstly screened for stationarity using Levin-Lin-Chu test, before running the panel regression. Normality testing was not undertaken because normality of data is not a presumption in panel data (Chelawat and Trivedi, 2016). The study also used Hausman specification test to choose the most suitable regression model for the analysis. The authors have also used the variance inflation factor (VIF) and correlation matrix to check the multicollinearity problem. Further, the authors have used based on prior studies (Chelawat and Trivedi, 2016; Dalal and Thaker, 2019; Hongming *et al.*, 2020) Wooldridge test for autocorrelation among variables of the study and Breusch–Pagan/Cook–Weisberg test for testing heteroscedasticity.

Empirical Analysis

Table 1 presents the descriptive statistics of all the variables considered in the study. It consists of ROA, ROE, ROCE, Tobin's Q, P/E ratio, and P/B Ratio, ESG disclosure score, firm size, firm leverage, firm age, and risk. The corporate value measures such as ROA exhibit an average of 8.68%, a maximum of 47.50%, and a minimum of -88.41% respectively. It can be seen that a few companies have their negative and declining performance which leads to accounting losses. The ROE reports an average value of 16.85%, and the range between maximum and minimum is 331.30 and -225.16%, which indicates that few companies incur financial losses. Similarly, the ROCE shows an average of 11.98% with a maximum and minimum of 83.38% and -316.15%, which indicates that few companies are not generating enough profit from its capital. In terms of marketing- based measure of corporate value, the mean value of Tobin's Q is 9.95, a maximum of 91.27%, and a minimum of 0.01, indicating that sample companies have a higher market value than the book value of total assets. The price earnings ratio generates an average of 74.14% and a maximum of 3176.32%, which is very high compared to a minimum of -0.83%. The Price to book value ratio shows an average of 16.11% and a maximum 4806.73%, which is also very high as compared to its minimum of 0.03%. The standard deviation of ROA, ROE, ROCE, Tobin's Q, Price to book value ratio, and the price-earnings ratio are 9.76, 25.16, 20.33, 206.21, 175.81, and 10.72 respectively. The higher standard deviations imply that the sample companies have significant accounting, financial, and market values.

Table 1: Descriptive Statistics.

Variables	Mean	Std. Deviation	Skewness	Kurtosis	Minimum	Maximum
ROA	8.6869	9.70978	-2.507	24.979	-88.41	47.50
ROE	16.8540	25.16629	3.370	75.582	-225.16	331.30
ROCE	11.9892	20.33903	-7.746	106.984	-316.15	83.38
P/E	74.1432	206.20925	12.275	171.617	-0.83	3176.32
P/B	16.1082	175.80561	26.646	724.740	0.03	4806.73
Tobin Q	9.9528	10.72258	2.993	13.179	0.01	91.27
ENV Score	33.47	14.956	0.112	-0.790	4	68
SOC Score	63.47	18.231	-0.113	-0.275	3	108
GOV Score	53.30	10.356	-0.272	-0.009	11	76
Quan ESGD Score	62.28	12.161	-0.306	0.094	15	88
Qual ESG Score	150.24	38.418	0.034	-0.483	26	243
FIRM SIZE	8.0531	1.79443	-1.640	8.364	-3.00	13.79
FIRM AGE	3.5251	0.77408	-1.735	5.184	0.00	5.06
LEV	0.5642	0.21185	-1.765	9.919	-1.25	1.00
RISK (Beta)	1.0545	0.36336	0.147	0.407	-0.40	2.40

Source: Author's Calculation

The descriptive statistics shows that the average ESG disclosure score of the sample companies is 62.28, which is very less compared to ESG disclosure scores in developed countries like USA, UK, Europe, and Germany. Generally, the average mean value of the ESG score is more than 70, indicating that companies achieve good returns in terms of ESG reporting. The maximum of 88 and minimum of 15 show that many sample companies have not provided enough ESG information. The quantitative score of environments, social, and governance dimension indicate that the companies are providing least information on environment dimension and most information on social dimension. The result also shows that the companies are providing more information on the mandatory disclosure as compared to voluntary disclosures. It indicates that the companies are fulfilling only the regulatory requirement in terms of ESG disclosure implying that companies in India are motivated by the legitimacy theory for providing the ESG information.

In order to use panel regression, it is necessary to test the stationarity of data using Levin-Lin-Chu panel unit root test (Levin Lin Chu, 2002). Table 2 displays the panel unit root test findings, including modified t statistics and probability results. All variables are statistically significant, indicating that the null hypothesis is rejected. Therefore, the data series is considered stationary at the level.

Table 2: Levin-Lin-Chu Test

Variables	Statistics	Probability
ROA	-35.008	0.000
ROE	-58.004	0.000
ROCE	-13.907	0.000
TOBIN Q	-45.966	0.000
P/B	-108.03	0.000
P/E	-230.01	0.002
ESGD	-67.342	0.000
F_SIZE	-18.001	0.000
F_AGE	-8.076	0.001
LEV	-98.023	0.000
RISK	-23.002	0.000

Source: Authors calculation

After checking stationarity of data, there is a need to check correlation among the independent variables and dependent and independent variables. Therefore, Table 3 reports the results of the correlation matrix to check the relationship between the variables. The correlation coefficients clearly show a high correlation between ROA and ROCE at 0.826, which indicates that ROA and ROCE are closely related. Similarly, the correlation coefficient of ROA and ROE is 0.63. It is noted from the results that ESG disclosure scores have positively correlated with ROA (0.07), ROCE (0.08) and Tobin's Q (0.148), respectively. In contrast, ROE (- 0.105), Price-Book ratio (-0.104) and price-earnings ratio (-0.08) negatively correlate with the ESG disclosure score. Further, the results reveal the absence of serial correlation between the variables, and most of the correlation coefficients are within the acceptable level of 0.8.

Table 3: Correlation Matrix

Correlations														
	ROA	ROE	ROCE	P/E	P/B	Tobin Q	ENV	SOC	GOV	ESG	FIRM SIZE	FIRM AGE	LEV	Beta
ROA	1													
ROE	.632**	1												
ROCE	.826**	.518**	1											
P/E	-	-	-.080*	1										
	0.015	0.008												
P/B	-	.501**	-0.022	-0.012	1									
	0.034													
Tobin Q	.171**	.092*	.139**	0.038	0.008	1								
ENV	.129**	-	-.129**	0.025	0.058	-	1							
		0.053				.167**								
SOC	0.062	-	-.076*	0.023	0.001	-	.602**	1						
		0.045				.125**								
GOV	0.026	-	-0.040	-0.045	-	-	.441**	.726**	1					
		0.038			0.007	.111**								
ESG	.073*	.105**	.089*	0.008	.104**	.148**	.779**	.923**	.815**	1				
FIRM SIZE	-.072*	-	-0.056	-0.032	-	-	.080*	-	-	0.024	1			
		.174**			.183**	.180**		0.029	0.018					
FIRM AGE	.096**	0.026	.100**	-0.002	-	-0.057	-	-	-	-	.444**	1		
				0.017	0.021	0.015	0.002	0.016						
LEV	.442**	.260**	.381**	-.082*	0.066	.083*	0.010	0.006	0.041	0.019	-	0.038	1	
											.155**			
Beta	-	-	-.122**	0.029	.083*	-	.103**	0.035	0.025	0.055	0.045	-0.010	-	1
	.205**	.098**				.128**						.096**		
**. Correlation is significant at the 0.01 level (2-tailed).														
*. Correlation is significant at the 0.05 level (2-tailed).														

Source: Authors calculation

The panel data analysis does not have a problem with the high correlation between variables (Vellimuthu *et al.*, 2024). Furthermore, the study re-examines the magnitude of the coefficients using the variance inflation factor (VIF). The average VIF values fall below the 10 criteria (Vellimuthu *et al.*, 2024). Additionally, the study uses the variance influence factor (VIF) to test the multicollinearity problem. Table 4 displays the findings. The regression models' VIF findings unequivocally demonstrate that the collinearity value is less than 3. It shows that the study variables are free from multicollinearity problems and that none of our models show a serious multicollinearity problem. The results are consistent with the previous studies (Ott and Longnecker, 2001; Gujarati, 2003).

Table 4: Variance Inflation Factors (VIF)

Variables	ROA	ROE	ROCE	TOBIN Q	P/B	P/E
ESG	1.23	1.01	1.01	1.01	1.01	1.01
F_Size	1.2	1.2	1.2	1.12	1.2	1.23
F_Age	1.17	1.14	1.17	1.09	1.17	1.28
LEV	1.04	1.04	1.04	1.04	1.04	1.04
Beta	1.01	1.01	1.01	1.03	1.01	1.02

Source: Authors Calculation

The study also employs Wooldridge test to check the autocorrelation among the variables of the study. The result of the test reported probability value (0.0787) signifying that data is free from the probability of autocorrelation. In order to check the heteroscedasticity problem, Breusch–Pagan/Cook–Weisberg test is employed and the results exhibit that data is from the heteroscedasticity problem, as the *p* value (0.002) is less than 5%, confirming the homoscedastic nature of the data. Therefore, the data can be further analysed.

After pre-testing data for panel regression analysis, the panel data regression results are presented in Table 5. It uses six dependent variables to measure the corporate value: ROA, ROE, ROCE, Tobin's Q, price-book ratio, and price-earnings ratio. The Hausman test is employed to select the most appropriate model among three. The dependent variable Return on asset (ROA) is used as an accounting- based measure to assess the firms' accounting performance. The result of the Hausman test shows a value of 65.68 with a probability value of 0.000, indicating that the most appropriate model for explaining the results is fixed effect model as compared to pooled OLS and RE. The independent variable ESG disclosure score results shows a positive and statistically significant relationship with ROA. The results confirm that companies with better ESG reporting and commitment have more profitability. This result is in line with the prior studies (Bodhanwala and Bodhanwala,

2018; Xie *et al.*, 2018; Dalal and Thaker, 2019 Conca *et al.*, 2021; Zhang *et al.*, 2022; Vellimuthu *et al.*, 2024). The firm characteristics such as firm size and beta were found to be negative and statistically significant with accounting performance measures (ROA), highlighting that larger firms have lower profitability.

The next dependent variable i.e., ROE is also used as a proxy of accounting- based measure of corporate value to assess the firm's financial performance. According to the Hausman test results, the fixed effect model is the most efficient model for explaining the results of ROE (14.19). The ESG disclosure scores beta coefficient has a positive and statistically significant relationship with ROE. It encourages enterprises to focus on ESG reporting disclosure in order to improve financial performance. Furthermore, the ESG disclosure score improves the firm's corporate value. The findings are similar with previous research (Friede *et al.*, 2015; Laskar and Maji, 2016; Aboud *et al.*, 2018; Bodhanwala and Bodhanwala, 2018; Vellimuthu *et al.*, 2024). Firm control variables such as size and beta have a negative impact on the firm's financial success. It demonstrates that larger enterprises are less profitable than smaller firms.

Similar to ROA and ROE, the study has used return on capital employed (ROCE) as an accounting- based measure. In line with ROA and ROE, the Hausman test result identified the FE model to be more efficient and the relationship between ROCE and ESG disclosure are statistically significant. The results are consistent with Chelawat and Trivedi (2016) and Bodhanwala and Bodhanwala (2018) indicating better ESG reporting have a positive effect on corporate value.

The study used three proxy of marketing- based measure of corporate value i.e., Tobin's Q, P/B Ratio, and P/E Ratio. In case of Tobin's Q also, Hausman test showed the fixed effect model more efficient as compared to pooled OLS and random effect model. The results reveal that ESG disclosure scores have a positive and statistically significant relationship with Tobin's Q. It indicates that higher ESG disclosure positively influences market performance. Also, it enhances the firm's positive image and then firm performance. These results are in consonance with prior studies (Chelawat and Trivedi, 2016; Yu *et al.*, 2017; Dalal and Thaker, 2019; Hongming *et al.*, 2020; Vellimuthu *et al.*, 2024). The control variable, firm size, and beta have negative and statistically significant associations with market performance (Tobin's Q).

Along with Tobin's Q, the other marketing- based measure used in P/B ratio, which is used to measure the firms book value performance, and the Hausman test value shows 22.32 (0.0004) for the P/B ratio, indicating fixed effect model to be used. The results show that ESG disclosure scores are positive and significant. It implies that the P/B ratio is significantly influencing the firm's market value performance. The public consider the P/B ratio while making investment decisions. The findings are in line with the signalling theory because the public will perceive the company's sustainability activities as a signal for a positive act. The results align with previous studies Balatbat and Carmicheal (2012); Yoon *et al.*, (2018).

Finally, the P/E ratio is used to measure the firms market value performance. On contrary to other marketing- based measure, the Hausman test value shows 7.41 for the P/E ratio, which confirms that the random effect model is the most appropriate model for explaining the results compared to pooled OLS and FE. The results indicate that ESG disclosure scores are both positive and insignificant. This implies that the P/E ratio has no substantial impact on the firm's market value performance. The public does not consider the P/E ratio when making investing decisions. The findings contradict the signalling hypothesis since the public will interpret the company's sustainability initiatives as a signal for a positive action. The findings are consistent with prior studies (Junius *et al.*, 2020; Ting *et al.*, 2020; Vellimuthu *et al.*, 2024).

Table 5: Regression results of ESG disclosure score and corporate value

Variable	ROA			ROE			ROCE			TOBIN Q			P/B			P/E		
	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect	Pooled OLS	Random Effect	Fixed Effect
Intercept	12.38** (-2.1)	6.12** (-1.29)	5.17** (-1.11)	62.85*** (3.8)	43.74** (-3.04)	5.65** (-0.27)	23.36** (-1.81)	23.26** (-1.94)	23.31** (1.28)	48.19*** (6.8)	54.06*** (11.1)	48.54*** (7.3)	39.71** (3.36)	37.86** (3.18)	25.47*** (1.27)	51.26*** (0.7)	32.39*** (5.81)	38.47*** (-7.12)
ESG	2.37** (-2.13)	1.08** (-1.1)	1.24** (-1.08)	8.76** (-2.82)	5.38** (-1.95)	6.81* (-1.85)	6.44** (-2.65)	6.49** (-2.83)	7.75** (-2.44)	5.25*** (-4.01)	7.66*** (-8.23)	8.78*** (-8.53)	65.44** (-2.93)	63.31** (-2.80)	113.01** (-3.2)	8.53 (-0.32)	-5.85 (-1.77)	-5.34 (-1.58)
F_Size	-0.31* (-1.54)	-0.69* (-0.71)	0.28** (-0.72)	-2.76*** (-4.92)	-3.18*** (-4.76)	-5.92*** (-4.87)	-0.55 (-1.25)	-0.35 (-0.68)	1.22* (-1.17)	-1.23*** (-4.77)	-0.43 (-1.64)	0.17 (-0.45)	22.19*** (-5.5)	22.81*** (-5.1)	57.84*** (-5.0)	-7.24 (-1.49)	6.91*** (-1.49)	7.26*** (-6.5)
F_Age	1.18*** (-2.55)	1.42** (-2.16)	2.51** (-1.47)	3.98** (-1.93)	26.52** (-2.25)	2.79** (-3.36)	2.74** (-2.73)	2.94** (-2.07)	-1.17 (-0.43)	-1.23*** (-0.54)	-0.29 (-0.31)	3.12* (-1.27)	13.91* (-1.49)	16.55* (-1.57)	74.49*** (4.52)	5.93 (-0.53)	-23.63*** (-3.5)	-26.89*** (-3.7)
LEV	19.22*** (-4.19)	12.49*** (-7.7)	4.24** (2.05)	27.29*** (6.4)	26.07*** (5.48)	24.11*** (3.5)	35.37*** (10.7)	30.01*** (8.05)	14.28** (2.5)	2.24 (-1.27)	0.21* (-0.12)	-1.73* (-0.84)	96.77* (-1.22)	41.68* (-1.27)	101.11* (-1.61)	-88.61** (-2.44)	2.11 (-0.35)	2.79 (-0.46)
Beta (Risk)	-4.19*** (-4.89)	-2.95*** (-4.70)	-2.55** (-3.99)	-4.20** (-1.75)	-3.13 (-1.61)	-3.16 (-1.54)	-4.43** (-2.36)	-2.59 (-1.59)	-1.07** (-0.61)	-3.02** (-2.98)	-1.69** (-2.71)	-1.37** (-2.16)	51.55** (2.99)	52.12** (-3.09)	48.36** (-2.51)	13.67 (-0.66)	-2.43 (-1.13)	-2.41 (-1.29)
R ²	0.24	0.22	0.38	0.28	0.18	0	0.17	0.2	0.16	0.23	0.15	0.17	0.35	0.25	0.15	0.11	0.15	0.09
Wald χ^2 -statistic	45.55	93.14	5.05	55.12	68.6	8	30.49	83	4.61	12.83	99.49	20.55	10.19	47.53	9.52	34.08	47.35	10.12
LM test (pooled vs. FE or RE)		255.88			191.66			119.62			118.32			99.86			64.32	
Hausman test (RE vs. FE)		65.58 (0.000)			14.19			21.11			22.64			22.32 (0.0005)			7.41	
					-0.0108			-0.0008			-0.0004						-0.1921	

Source: Authors calculation, *** p < .01, ** p < .05, * p < .1, t statistics are given parentheses

Discussion & Recommendation

The present study investigates the extent of ESG reporting practices of selected sample companies and how ESG disclosure scores influence the firm operational, financial, and market value performance of Indian firms. The study examines the efficiency of ESG disclosure scores on firm performance using 255 sample companies' data which are collected from their annual reports through developed ESG framework for the period from 2019 to 2023. The study used panel regression models such as pooled OLS, fixed, random effects. The ESG scores collected thorough developed framework indicated that the sample companies a are providing least information about environment dimension and the maximum information on social dimension. It indicates that the companies are motivated by the legitimacy theory, thus, fulfilling regulatory requirement only. The empirical results found that ESG disclosure scores significantly and positively influence the corporate value indicating companies with better ESG disclosures ultimately improve the corporate value.

This analysis helps researchers and businesses determine whether providing more ESG information continues to have an impact on a company's performance and valuation. The Study's empirical findings will help government officials and politicians understand how their regulations affect corporate performance and help them to make better policies. The findings will also assist business practitioners in overcoming concerns about the possible detrimental impact of ESG measures on firm performance, thereby promoting innovative and strategic adjustments in business models to capitalise on ESG prospects.

Overall, this study contributes valuable insights, However, based on the findings of this study, few recommendations can be made to enhance the adoption and effectiveness of ESG reporting in India which can contribute to improved corporate value. First, the regulatory authorities, such as SEBI (Securities and Exchange Board of India), should ensure stringent compliance and disclosure requirements for ESG reporting. A standardized ESG reporting framework particularly for Indian companies can provide consistency and comparability across industries. Second, Companies, particularly small and medium enterprises (SMEs) should be educated about the benefits of ESG reporting in enhancing stakeholder trust and corporate valuation. Third, Leveraging advanced technologies like AI, blockchain, and data analytics can enhance the accuracy, transparency, and efficiency of ESG reporting. Indian corporations should invest in digital tools to streamline their sustainability data collection, analysis, and disclosure processes. Fourth, companies must recognize ESG's role as a value driver rather than a compliance obligation. Investing in clean energy, social welfare initiatives, and strong governance mechanisms can lead to long-term financial and reputational benefits. Finally, stakeholders, including investors and consumers, should be educated on the importance of ESG practices to foster demand for responsible corporate behaviour. By implementing these measures, Indian corporations can maximize the dual benefits of improving corporate value and contributing to sustainable development.

Limitations & Future Scope of Research

This study provides valuable insights into the impact of ESG reporting on corporate value in India. However, several areas remain unexplored, offering opportunities for future research. First, as this study is focused on all companies listed in BSE-500 index, the future studies can focus on sector-specific impacts of ESG reporting, examining variations in the influence of ESG practices across industries such as finance, manufacturing, technology, and energy. This can provide tailored insights into the nuances of ESG reporting for different sectors. Second, current study is limited in scope, spanning only five years from 2019 to 2023, therefore, conducting longitudinal research will offer a more comprehensive understanding of its effects over time, considering evolving market conditions and regulatory changes. Third, Comparing the impact of ESG reporting on corporate value in India with other countries, particularly emerging and developed economies, could provide a global perspective and highlight best practices applicable to Indian corporations. Fourth, most research focuses on large corporations, but the implications of ESG reporting for SMEs remain underexplored. Future studies could evaluate the challenges and benefits of ESG adoption for smaller enterprises in India. Fifth, Investigating the behavioural aspects of corporate decision-making regarding ESG practices and reporting can shed light on the motivations and barriers influencing the adoption of ESG frameworks. Lastly, by advancing the understanding of ESG disclosure's influence on corporate value, this study aims to inspire further exploration and refinement in sustainable corporate practices and their financial implications.

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Impact of On-Board Service Quality on Passengers' Satisfaction: Mediating Role of Safety and Security at Konkan Railway

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Abstract

The study examines the influence of on-board service quality on passenger satisfaction, particularly emphasising the mediating effect of safety & security in the context of Konkan Railway. A systematic survey conducted at Madgaon station (NSG-2) resulted in 690 valid responses from passengers, employing a 35-item questionnaire to assess critical service dimensions such as basic amenities, cleanliness, safety & security, staff behaviour, food & beverages, and other services. Structural Equation Modelling (SEM) was utilised to evaluate hypotheses and examine the interrelationships among these constructs. This research offers practical insights for Konkan Railway, highlighting the necessity for a comprehensive, integrated approach to enhance both direct and mediated routes to satisfaction. By emphasising safety & security, the railway can enhance the beneficial impacts of service improvement, thereby providing an improved travel experience that meets passenger expectations. The results provide a source for improving service quality and developing customer-focused policies within the railway industry. Further, it will indicate that every dimension of service quality significantly impacts passenger satisfaction, with safety & security acting as an essential mediator. The presence of basic amenities and a high standard of cleanliness significantly contribute to overall satisfaction while fostering enhanced perceptions of safety. The conduct of staff and the provision of food and beverage services play significant roles, both independently and through their influence on intermediary factors. Further highlight the interrelated aspects of service quality, indicating that improvements in a particular service domain can lead to enhancements in others, thereby improving overall satisfaction.

Keywords: Amenities, Cleanliness, Konkan Railway, Passenger Satisfaction, Safety & Security.

Introduction

The Konkan Railway, spanning approximately 740 kilometres through the Western Ghats, is a vital transportation link connecting Mumbai and Mangalore, traversing the states of Goa, Karnataka, and Maharashtra. With its rugged topography, this impressive railway network was built with significant engineering advances in the early 1990s. The Konkan Railway was initiated to meet passenger demand and improve West Coast connectivity. Konkan Railway has taken several steps to improve passenger amenities to meet the latest challenging and demanding desires for passenger like as escalators at Non-Suburban Group (NSG)- 2 and NSG-3 Stations are notable improvements, and further enhancements include platform shelters & surface enhancement, accessible restrooms, renovated waiting rooms with new benches, video walls, free Wi-Fi at stations, and other amenities. E-catering and local food vendors have been introduced to accommodate different local tastes on the platform. As part of its commitment to sustainable energy, the Konkan Railway Corporation built solar power plants at Non-Suburban Group stations- 2, 3 & 4. To promote tourism and related activities, the Railway has introduced specialised train services for festivals like the Ganapati festival, Onam and many more. These efforts demonstrate the company's dedication to passenger satisfaction and regional development.

Review of Literature:

In the realm of transportation, rail transport plays a vibrant role in economic progress, although there are various modes of transportation in the country. Rail transport is the most convenient, cost-effective, economical and safe option (Mageshwari & Vasanthi, 2020). To effectively compete with alternative transportation modes, the railway industry must gain insights into passengers' perspectives on service quality, which is crucial for enhancing passengers' satisfaction levels (Margaret Divya & Devi, 2020). The enhancement of safety and security, along with the optimisation of basic amenities, sanitation, catering, healthcare, and timeliness, determines the overall service quality of the Railway system (Sheeba & Kumuthadevi, 2013). For sustainability, distinction and market competitiveness, a critical need exists to improve service quality, passenger pleasure, and loyalty within the railway sector (Rahim, 2016). As per Principal Component Analysis, security and safety,

comfort, infrastructure quality, and ticket procuring services significantly influence the Metro station and train passenger satisfaction (Saw et al., 2020). The Importance Performance Analysis classifies these indicators with the indicators for nationwide enhancement in intercity train service quality to encourage productivity (Jomnonkwao et al., 2020). Railqual, introduced (Prasad & Shekhar, 2010), serves as an assessment tool for improving railway passenger services, aiding management in identifying areas for business development. (C.G., 2017) says that a long-term commitment to intentional performance and vital service governs passenger-pleasing facilities, thereby improving services and benefiting passengers and the economy (Thanaraju et al., 2019). Recognising the influence of passenger satisfaction on loyalty (Oktavia & Dwiatmoko, 2022), the role of service excellence in boosting passenger happiness, eventually fostering customer loyalty, is prominent.

Theoretical, Contextual and Hypothesis Development:

To fully understand the service quality attributes that affect passenger satisfaction on the Konkan Railway, the researcher conducted qualitative interviews with thirty respondents who have travelled on the Konkan Railway for more than four trips in their lifetime and ten experts who are working in the domain area of Konkan Railway department. The respondents' satisfaction with railway services were influenced by their perceptions of on-board and off-board service quality and specific preferences and perceptions regarding safety & security measures. This study will identify and examine on-board attributes like basic amenities, cleanliness, safety & security, food & beverages, staff behaviour and other services using service quality and passenger satisfaction theory called SERVPERF. The SERVPERF model assesses service quality based on tangibles, reliability, responsiveness, assurance, and empathy. Additionally, the study examines how perceived safety and security mediate the relationship between on-board service quality attributes and satisfaction. Given the importance of public transportation safety, understanding how passenger perceptions of safety and security affect satisfaction is crucial.

H0_a- There is no statistical relationship between Basic Amenities and Passenger Satisfaction.

H0_b-There is no statistical relationship between Cleanliness and Passenger Satisfaction.

H0_c-There is no statistical relationship between Safety & Security and Passenger Satisfaction.

H0_d-There is no statistical relationship between Staff Behaviour and Passenger Satisfaction.

H0_e- There is no statistical relationship between Food & Beverages and Passenger Satisfaction.

H0_f- There is no statistical relationship between Other Services and Passenger satisfaction.

Mediating Hypotheses:

Safety and Security mediate passenger satisfaction, according to research that shows safety concerns can overshadow other service features if not addressed in Rail transportation (Lai & Chen, 2011). Proper safety and security protocols improve passengers' comfort and other services on railways. Studies reveal that passengers prioritise safety and security, which increases their satisfaction and service ratings (Koo et al., 2015). Adequate safety and security regulations make passengers comfortable, improving Konkan Railway service quality. The passengers feel protected when on-board staff shows genuine interest in assisting them with their difficulties; it fosters a sense of security and trust (Transport Focus, 2016). Effective communication and disciplined behaviour by the staff, further enhance this trust, encouraging passengers to interact without fear. Positive staff behaviour significantly boosts passenger's confidence and satisfaction, which makes their needs and expectations easier. Food and beverage and other onboard services are more enjoyable in a secure environment. Safety and security's mediating role emphasises its fundamental importance in passengers' pleasure, underlining that a safe travel experience maximises all other service benefits (Lasarudin et al., 2022). The above insight leads us to propose the following hypothesis and further sub-classify:

H0_g- There is no significant indirect relationship between onboard services and Passenger Satisfaction mediated by safety and Securities.

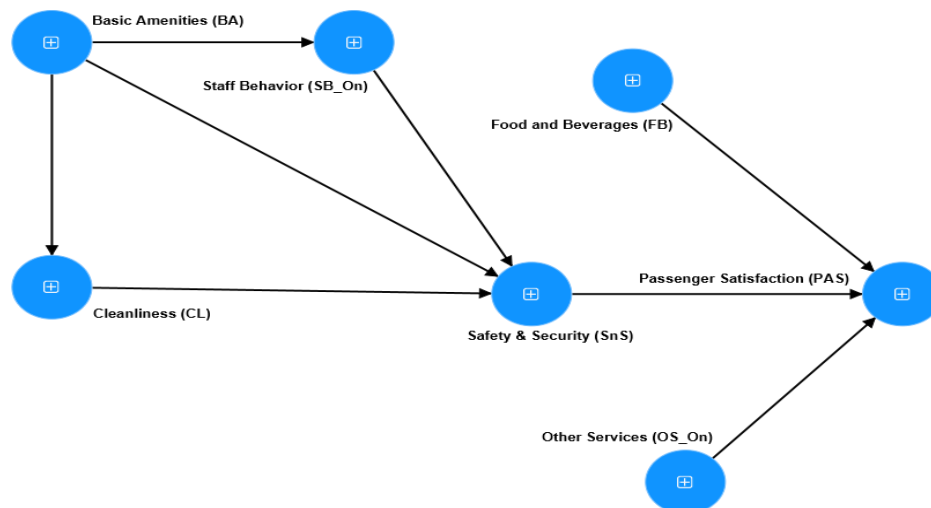


Fig. 1: Conceptual Model

The Konkan Railway conceptual model of passenger satisfaction (Fig. 1) examines how service attributes affect passenger satisfaction. The exogenous variables in this model are basic amenities, cleanliness, staff behaviour, safety & security, food & beverages, and other on-board services that reflect the endogenous variable i.e. passenger satisfaction. In this model, passenger satisfaction measures overall satisfaction with the railway service. The study examines the correlation between these exogenous variables and the endogenous variable of passenger satisfaction to pinpoint opportunities for strategic enhancement in the quality of Konkan Railway services. Railway management can improve passenger satisfaction by prioritising their basic needs and ensuring safety & security by integrating these elements into the service framework.

Objectives of The Study:

Research objectives are crucial in guiding the studies and ensuring that the researcher can achieve meaningful results. The objectives for this paper are as follows:

1. To assess the impact of On-board service quality attributes on rail passenger satisfaction.
2. To explore the mediating effect of Safety & Security on passenger satisfaction.

Research Methodology:

The research methodology involves a quantitative approach, utilising surveys to collect data from rail passengers travelling via the Konkan Railway. Structural Equation Modelling (SEM) was employed to assess the complex relationship between observed and latent variables, and simultaneously, it will test multiple hypotheses and provide a comprehensive understanding of the underlying data structure of on-board service quality and the mediating role of safety & security on passenger satisfaction.

Data Analysis:

This analysis provides insights into the direct and indirect relationships between factors. Table 1 shows the statements related to on-board service quality with their codes.

Table No. 1 : Details of items with their codes

Codes	Items
BA1	A sufficient number of berths are available in the coach.
BA2	A sufficient number of functional lights, fans, and charging points are provided in the coach.
BA3	The coaches are equipped with comfortable seats.
BA4	The coaches are equipped with adequate legroom.
BA5	Enough space in the coach for passenger mobility.
CL1	Cleanliness is maintained in the train.
CL2	Sufficient water supply in the bathrooms' washbasins and toilets is available.
CL3	Regular cleaning and sanitisation of the toilet, bathroom, and wash basins is undertaken.
CL4	Cleanliness and hygiene are maintained by the Pantry Services.
CL5	Garbage bags and regular collection of waste in the coach are provided.
SnS1	There is provision for the safety of Passenger (s) while travelling.
SnS2	The Railway Protection Force is deployed in the coach.
SnS3	There is a provision for CCTV surveillance in the coach to monitor passenger safety.

SnS4	Safety measures are taken by the staff in case of emergency during travel.
SnS5	There is security for the luggage and belongings in the coach.
SB1	The Travelling Ticket Examiner's (TTE) conduct is courteous.
SB2	The Travelling Ticket Examiner's (TTE) conduct is helpful.
SB3	The Travelling Ticket Examiner (TTE) is knowledgeable.
SB4	The behaviour of the pantry staff is friendly and courteous.
SB5	The staff are alert and helpful in case of emergency.
FB1	Food and beverage facilities are available and accessible.
FB2	Food and beverages are reasonably priced.
FB3	Sufficient quantities of food and beverages are available at a reasonable price.
FB4	There are various choices in varieties of food and beverages.
FB5	Hygiene and cleanliness of the food and beverage facilities are standard.
OS1	Steps are taken to control the hawker's menace in the coach.
OS2	A sufficient number of on-board shopping facilities are available.
OS3	Space for baby care facilities is provided in the coach.
OS4	Free Wi-Fi connectivity is available.
OS5	Entertainment facilities are available in the coaches.
PAS1	How pleased are you with the safety and security measures executed on board?
PAS2	How content are you with the punctuality and timeliness of the train's departure and arrival?
PAS3	To what extent are you satisfied with the courtesy and assistance when asked for? Is it provided by the on-board staff?
PAS4	How satisfied are you with the quality, hygiene and variety of food and beverages service provided on-board?
PAS5	How satisfied are you with the availability and cleanliness of restrooms on board?

Source: Primary Data

Sampling and Data Collection:

The study examines Madgaon Konkan Railway (KR) station, i.e. NSG-2 passengers' preferences and satisfaction. The embarked and disembarked respondents were surveyed on a 5-point Likert Scale from Strongly Disagree to Strongly Agree. Surveys were conducted from Feb.- Aug. 2024. At the station, 740 passengers' feedback was collected using a non-probability convenient sampling technique to access a diverse and readily available pool of respondents (Kumuthadevi, 2019; Mageshwari & Vasanthi, 2020; Margaret Divya & Devi, 2020; Saw et al., 2020). To ensure the statistical robustness of the sample (Faizan et al., 2018; J. F. Hair et al., 2017; Kwong-Kay, 2013; Magno et al., 2022) recommends a minimum of 5 to a maximum of 20 cases per observed variable. Applying this guideline to the 35-item model comparison shows that 175-700 respondents are needed. This range is necessary to represent the variable in the model and ensure the reliability and validity of the data; further, the following sample size improves research credibility and data interpretation. The scale was validated by five experienced researchers, three Konkan Railway personnel and two passengers (Denise F. Polit, Cheryl Tatano Beck, 2005; Yusoff, 2019), and the preliminary study was conducted on 185 passengers and analysed. The Cronbach alpha results are basic amenities were 0.804 reliable with six items: cleanliness.0908 with six elements; Safety & Security 0.873 with six items and staff behaviour 0.892 with six items; food and beverages 0.891 with six items, and other services 0.807 with six items. Kaiser Meyer Olkin and Bartlett's tests were 8.43 (Ayuni & Sari, 2018; Reddy & Kulshrestha, 2019). The major data collection was collected from 92 trains that operate on the Konkan railway route, including daily Passenger Trains, Express, Rajdhani, Sampark, Duronto, and Tejas Express trains.

Data Screening:

Preparing for data analysis involves thorough screening of the data. A total of 740 respondents filled out the questionnaire, but few were rejected due to incompleteness and outliers. The final sample size considered for analysis was 690. This process included evaluating normality, outliers, missing values, and demographics. Further data analysis and research findings briefly describe respondents' gender, age, marital status, educational qualification, occupation, annual income, and rail trip spending. Out of 690 responses, 57% were male and 43% female. The majority of the respondents were aged 31-40 (65%), followed by 18-30 (15%), 41-50 (9%), 51-60 (8%), and above 60 (4%). Also, 58% were unmarried and 42% married. The education qualifications are 3.9%, 5.1%, 16.4%, 14.9%, 41.1%, 17.5%, and 1.1%: SSC, HSSC, Diploma, Graduation degree, and Postgraduate degree respectively. The Salaried persons and self-employed contributed 38.4% and 30.7%, respectively, followed by professionals (10%), students (9%), business persons (5.8%), unemployed (3.4%), and others

(2.7%). Annual income below Rs. 3 lakh was 56.8%, 20.5% to Rs. 5 lakh, 8.3% to Rs. 7 lakh, and 14.4% above Rs. 7 lakh. Up to Rs. 5,000- 49.1%, Rs. 10,000- 27.4%, Rs. 15,000- 11.9%, and above Rs. 15,000- 11.6% were spent on railway transport annually.

Common-Method Variance Bias:

To determine the possible presence of common-method variance bias among variables, the study has employed (Maxwell & Harman, 1968) a one-factor test. The researcher followed the principles and methodology outlined (Podsakoff et al., 2003) to conduct a one-factor test, as described by (Maxwell & Harman, 1968). To conduct this test, all the measurement scale items were subjected to a Principal Component Analysis with varimax rotation. This facilitated the identification of indicators of a single factor via factor analysis. The outcome derived from seven distinct components obtained from six measurement constructs (Basic Amenities, Cleanliness, Safety & Securities, Food & Beverages, Staff Behaviour, and Other Services) converged over six iterations of rotation. The results indicate that this study does not exhibit any issues related to common method variance bias.

Measurement Model:

The measurement model was reviewed through several key criteria to ensure its consistency and stability, as outlined by (J. Hair et al., 2014). This study employed composite reliability to assess the model's dependability, also known as internal consistency, alongside convergent and discriminant validity to test the measurement model (J. F. Hair et al., 2019; Ibrahim et al., 2023). Internal consistency was evaluated using composite reliability (ρ_c), which measures the internal consistency and reliability of the construct, with Cronbach's Alpha and composite reliability values exceeding 0.70, specifically ranging from 0.764 to 0.874 for Cronbach's Alpha and 0.835 to 0.909 for composite stability. The assessment of convergent validity, utilizing Average Variance Extracted (AVE), revealed that all constructs achieved AVE values exceeding 0.50, with a range from 0.505 to 0.667, indicating a robust representation of the constructs. The assessment of discriminant validity was conducted through the application of the Fornell-Larcker criterion alongside the Heterotrait-Monotrait ratio (HTMT). The Fornell-Larcker criterion entails an evaluation of the square root of the AVE values across all constructs in relation to their highest squared correlation with other constructs. In contrast, the Heterotrait-Monotrait ratio focuses on the assessment of correlation ratios. The findings laid out in Table 2 indicate that the square root of each construct's AVE exceeded the highest correlation with other constructs, while the HTMT ratios remained below the 0.85 threshold. The results of these evaluations substantiated that the discriminant validity of all constructs within the proposed model was successfully attained (Ibrahim et al., 2023). Table 2 represents the Fornell-Larcker criterion and HTMT ratio.

Table No. 2. Fornell-Larcker criterion and HTMT Ratio

	BA	CL	FB	OS	PAS	SB	SnS
BA	0.711	0.812	0.595	0.486	0.539	0.558	0.81
CL	0.711	0.816	0.542	0.548	0.538	0.44	0.784
FB	0.492	0.464	0.761	0.532	0.58	0.807	0.846
OS	0.411	0.46	0.431	0.743	0.674	0.412	0.715
PAS	0.459	0.467	0.491	0.566	0.802	0.532	0.679
SB	0.447	0.384	0.69	0.345	0.461	0.816	0.712
SnS	0.659	0.659	0.678	0.566	0.558	0.58	0.725

Source: Primary Data Note: The square roots of the AVE are diagonal and italicised. Below the diagonal elements is the correlation between the construct's value, and above the diagonal elements are the HTMT values.

Structural Model:

The structural model in Smart PLS represents the hypothesised relationship between latent variables, depicted through path diagrams where the arrow shows causal influences. This model is constructed after ensuring a robust measurement model with constructs operationalised by specific indicators. Path coefficients, generated by regression analysis, indicating the strength and direction of relationships, are assessed statistically via bootstrapping to determine significance levels, i.e. p-value. Fig 2 shows the structural model.

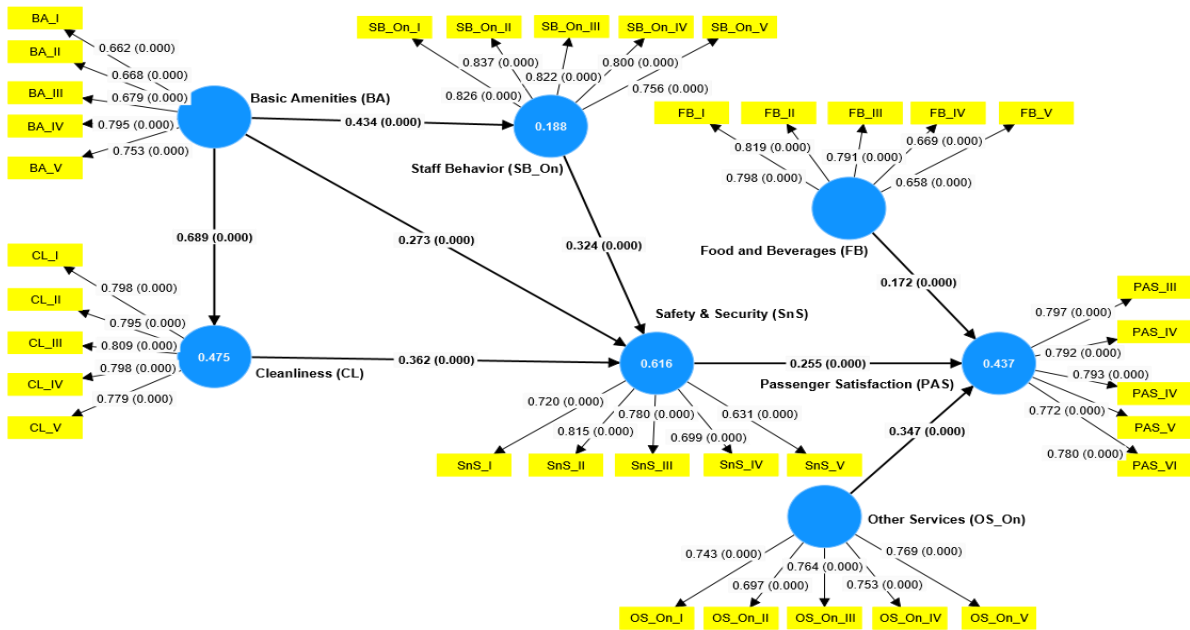


Fig. 2 Structural Model

Table 3 presents the Smart PLS model's hypothesis testing analysis of construct relationships' strength and significance. The study tests hypotheses about how Basic Amenities (BA), Cleanliness (CL), Staff Behaviour (SB), Safety and Security (SnS), Food and Beverages (FB), and Other Services (OS) affect Passenger Satisfaction.

H0_a shows a strong positive effect between basic amenities and passenger satisfaction, with a beta value of 0.169 and a very high t-value of 4.966. This suggests that improving basic amenities significantly boosts on-board passenger satisfaction. With a beta value of 0.092 and a t-value of 4.713, H0_b shows that cleanliness is crucial to passenger satisfaction. H0_c shows a positive coefficient of 0.255 and a t-value of 5.161, indicating that effective safety and security measures moderately improve passenger satisfaction. A beta value of 0.083 and a t-value of 5.823 show that superior amenities positively affect staff behaviour (H0_d), indicating a statistically significant effect. Better amenities may improve staff behaviour and satisfaction. H0_e shows that high-quality food and beverage services significantly improve passenger satisfaction with a beta value of 0.172 and a t-value of 3.832. H0_f shows a stronger positive effect of other services on passenger satisfaction with a coefficient of 0.347 and a t-value of 8.412. This shows the importance of miscellaneous services in improving travel and passenger satisfaction. The analysis shows that basic amenities, cleanliness, safety and security, staff behaviour, food and beverages, and other services significantly affect Konkan Railway passenger satisfaction. The findings emphasize the importance of a holistic approach to service quality, where improvements in each area improve passenger satisfaction.

Table 3: Structural Analysis

Hypotheses	Relationship	Original sample (O)	T statistics	P values	Result
H0 _a	BA -> PAS	0.169	4.966	0*	Reject
H0 _b	CL -> PAS	0.092	4.713	0*	Reject
H0 _c	SnS -> PAS	0.255	5.161	0*	Reject
H0 _d	SB_On -> PAS	0.083	5.823	0*	Reject
H0 _e	FB -> PAS	0.172	3.823	0*	Reject
H0 _f	OS_On -> PAS	0.347	8.412	0*	Reject

Source: Primary Data Note: * indicates the value is significant at the 5% level.

Mediation Analysis:

Table 4 outlines the results of a mediation analysis where multiple service factors are examined for their indirect effects on passenger satisfaction through intermediate variables like cleanliness, safety & security, and staff behaviour. Each pathway in the analysis demonstrates how the initial service aspects influence passenger satisfaction by impacting other related service qualities.

In the above analysis, all paths show significant effects, with the t-value indicating strong statistical significance and a p-value of zero across all tested relationships. This suggests that the mediated relationships are strong and reliably impact passenger satisfaction. The indirect effects associated with basic amenities, cleanliness, and staff behaviour underline the significance of these foundational service elements in fostering a secure and satisfactory passenger experience through the enhancement of intermediary service qualities. The notable indirect pathways indicate that cleanliness not only has a direct impact on passenger satisfaction but also serves as a vital mediation factor, improving protection and security and thereby improving levels of passenger satisfaction. In a comparable manner, basic amenities and the conduct of staff have a consequential, crucial impact on passenger satisfaction as they enhance perceptions of safety and security among travellers. The mediated pathways highlight the intricate relationships among service factors within the railway sector, illustrating how advancement in a particular area can reverberate across various service dimensions, ultimately leading to a rise in overall passenger satisfaction.

Table 4: **Mediation Analysis**

Hypotheses	Relationship	Original sample (O)	T statistics	P values	Result
H0 ₁	Basic Amenities -> Cleanliness -> Safety and Security -> Passenger Satisfaction	0.064	4.587	0*	Reject
H0 ₂	Cleanliness -> Safety and Security -> Passenger Satisfaction	0.092	4.713	0*	Reject
H0 ₃	Basic Amenities -> Staff Behaviour -> Safety and Security -> Passenger Satisfaction	0.036	4.39	0*	Reject
H0 ₄	Staff Behaviour -> Safety and Security -> Passenger Satisfaction	0.083	4.643	0*	Reject
H0 ₅	Basic Amenities -> Safety and Security -> Passenger Satisfaction	0.07	3.838	0*	Reject

Source: Primary Data Note: * indicates the value is significant at the 5% level.

Findings:

This study presents important insights regarding the factors that affect passenger satisfaction on the Konkan Railway, highlighting the interrelation of service dimensions. The structural model analysis demonstrates that all evaluated service constructs significantly influence passenger satisfaction, with path coefficients reflecting positive and statistically significant relationships. Basic Amenities, with a beta value of 0.169, significantly contribute to passenger satisfaction, indicating that improving essential services like seating, lighting, and sanitation enhances the travel experience. Cleanliness, with a beta value of 0.092, is a key factor that directly influences satisfaction and mediates the perception of safety & security. Safety & Security measures (beta = 0.255) enhance satisfaction, highlighting their role in ensuring a secure travel environment. Staff behaviour, indirectly tied to satisfaction via better amenities and safety perceptions, highlights the importance of service personnel in influencing passenger experiences. High-quality food and beverages (beta = 0.172) and other services (beta = 0.347) significantly enhance satisfaction and highlight the importance of comprehensive service offerings. Mediation analysis shows how service improvements lead to increased passenger satisfaction through enhanced cleanliness and staff behaviour, which boost perceptions of safety and security. Essential facilities indirectly influence factors such as cleanliness and staff behaviour. Cleanliness influences various aspects, highlighting its essential role in service quality. The result demonstrates the interrelation of service enhancement, indicating that advancements in one domain beneficially influence others, thereby enhancing the passenger experience. This highlights the importance of railway service providers adopting a holistic approach, concentrating on both direct service elements and their interrelations to improve passenger satisfaction.

Discussion:

The examination reveals that multiple essential factors play a significant role in influencing passenger satisfaction within the circumstances under investigation. Particularly, variables like basic amenities, cleanliness, safety & security, staff behaviour and other services have been acknowledged as crucial factors, each exerting a positive influence on overall passenger satisfaction levels. Including amenities, like comfortable seating and adequate space for passenger movement within the coach, enhances the overall experience for passengers (Geetika et al., 2016; Ghosh et al., 2017). Similarly, a commitment to maintaining high standards of cleanliness within the travel, setting positively influences satisfaction levels, highlighting the importance of hygienic facilities and well-kept environments (Vos & Hagen, 2019). Furthermore, efforts aimed at ensuring safety and security measures, both in transit and within terminal facilities, positively influence passenger

satisfaction, fostering a sense of trust and comfort among travellers (Gajendran, 2013; Suman et al., 2018). Furthermore, the behaviour and degree of professionalism demonstrated by personnel play a crucial role in shaping passengers' perceptions and overall satisfaction with their travel experience. The finding emphasises the complex and varied dimensions of passenger satisfaction, illustrating the significance of numerous operational and service-related factors in shaping the overall quality of the travel experience.

Conclusion:

In conclusion, the analysis highlights the complex dimensions of passenger satisfaction, which is shaped by various essential services such as basic amenities, cleanliness, safety & security protocols, staff behaviour and other services. The provision of basic amenities, like comfortable seating, adequate legroom, mobility for passengers, and advanced facilities, improves passenger pleasure (Dr.S.Kanthimathinathan, 2019). The significance of cleanliness and sanitation in the coaches cannot be overstated when considering the overall passenger experience and hygiene standards (Anbupriya & Subadra, 2017). Implement a systematic waste management protocol by regularly collecting garbage from coaches and supplying passengers with garbage bags for proper disposal. Prioritize enhanced safety and security measures, such as increased surveillance, patrolling, and emergency response systems, to ensure a secure travel environment. Additionally, maintain a high standard of cleanliness through frequent cleaning schedules, timely water refills and sanitation management to improve the overall passenger experience and comfort. Across journey and terminal facilities fosters passenger trust and a sense of protection. Thorough safety measures and recognised security precautions enhance travellers' conceptions of safety and overall enjoyment of their trips (Abdul et al., 2015; Collart-dutilleul et al., 2018; Coppola & Silvestri, 2020). The conduct of staff significantly influences passenger satisfaction levels. The professionalism, helpful nature, kindness, and punctuality significantly impact the quality ratings of passenger service and overall satisfaction levels (Antwi et al., 2020; P, 2019; Souca, 2011; Zangmo et al., 2014). Constructive interactions among staff can enhance the well-being and comfort of passengers. The result indicates that it is essential for railway authorities to enhance facilities, hygiene, safety, and security measures, as well as staff training cum behaviours, in order to elevate passenger satisfaction and overall travel experiences. By emphasising these variables, service providers can surpass passengers' expectations and foster loyalty along with favourable endorsements within the travel industry.

Limitation of the Study:

The research delineates certain limitations that must be acknowledged when evaluating the findings. Reliance on data supplied by participants may result in response bias, thus undermining the impartiality of the results. The investigation is limited to the Konkan Railway passengers, restricting the application of the results to other railway systems or regions working within or outside the country. The model eliminated external factors such as weather-related delays or socio-economic variables that might influence passenger pleasure. Furthermore, the cross-sectional form of the data restricts the ability to detect variations in satisfaction over time or assess the long-term impacts of the service. Certain variables, like additional services, may not be clearly operationalised, leading to potential ambiguity in interpretation. Furthermore, SERVPERF emphasises performance solely, neglecting the essential influence of passenger expectations on the formation of satisfaction. It may overlook service dimensions' dynamic and interdependent characteristics, thereby constraining its relevance in intricate environments such as railways.

Suggestions for Future Direction:

Enhancing passenger satisfaction in the Konkan Railway can be approached through various strategies. Primarily, enhancing on-board services, including cleanliness, water refills, and effective garbage management, is essential for ensuring passenger comfort. It is important for staff to undergo professional and customer service training to enhance the passengers' relations and foster trust. Consistent monitoring, patrols and surveillance are essential for ensuring passenger safety, which in turn influences overall satisfaction. Service providers should also consider the importance of Wi-Fi, entertainment options and improved food quality. Ultimately, consistent feedback, both online and offline, can effectively address the needs of passengers and yield actionable insights for ongoing enhancement. These elements are crucial for Konkan Railway to refine the overall experience and align with passenger expectations.

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Utilization of Intangibles Assets and the Performance of Public Sector Enterprises in India: DEA Analysis

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Abstract

Recent upsurges in intangible investment to boost Central Public Sector Enterprises' (CPSEs') capacity for production have raised a number of questions regarding the direction of decisions and the real management space that makes them a reality. A somber An alarming trend of crisis in the assessment and distribution of intangibles was shown by this study on the value of intangible expenditure and capitalization in enhancing future returns. Using the input-oriented Variable Returns to Scale (VRS) weighted measure-specific Data envelopment analysis (DEA) model with the R software, The contribution of the four inputs—software spending, other R&D expenditures, materials, and employee costs—to a set of productive activities that encompass revenue and net-value-added is critically examined in this study. These operations are more consistent in improving production capacity and profit. The study is based on Nabaratna Enterprises' dataset from the last ten years. Using Data Envelopment Analysis (DEA), this study compares the technical and scale efficiency of the CCR Charnes–Cooper–Rhodes (CCR) and Banker–Charnes–Cooper (BCC) models to assess the effectiveness of Decision-Making Units (DMUs). While factors associated with creative activities, such R&D and software investment, could not duplicate the same discriminative power in alternative models, the baseline DEA model successfully differentiated between efficient and inefficient DMUs. Despite maintaining an average technical efficiency of about 70%, the BCC model in particular incorrectly categorized a larger percentage of DMUs as efficient, with the percentage of efficient units sharply increasing from 21.25% to 56–60%. The study also shows that scale efficiency had a greater impact on some units' efficiency than technical efficiency, including National Thermal Power Corporation Limited (NTPC), suggesting inefficiencies in management. Bharat Petroleum Corporation, on the other hand, could do better by expanding its business. Additionally, the data showed that R&D and software expenditures had a major effect on some units' efficiency, especially NTPC. With only 11% of units operating at best practice levels and a lack of consistency between DMUs, the study emphasizes the significance of size in efficiency scores. The multidimensional performances of the firms over the study period were not consistent, according to the results.

Keywords: R&D Spending, Measure-Specific Optimization and DEA Efficiency Ratings

Introduction

The study explores the business performance is affected by varies intangible spending, especially in R&D. R&D expenditure and financial results are positively correlated, according to recent studies. The accounting field highlights the importance of varied expenditure in fostering innovation and competitiveness, despite skepticism about it. Businesses gain more when innovations are broadly adopted (Areti & Kostas, 2017).

There has been much discussion in recent years about the diversity aspects of intangible spending and how it affects business performance. A number of trends were highlighted by the accounting field and findings. (Areti & Kostas, 2017);(Ferdaous & Marian, 2020). Notwithstanding the diverse trends of various intangible expenditure metrics that lead to disparate firm rankings (Jun-You, 2014);(Negin & Jafar, 2018); and It is crucial for businesses to shatter the uncertainty and suspicion around varied intangible spending (Wang E. C., 2007); (Tuan & Nguyen, 2022). It appears reasonable to diversify R&D spending to some extent in order to withstand the intense competition, and the academic community will keep working in this area to replicate some of the salient characteristics of that business unit.

Following historical results (Jeongjin & Juneseuk, 2017);(Marios & Palitha, 2020); using a systematic process to transform a technology's potential into an R&D plan (Chinho & Cheng-Yu, 2012), It is found that Spending on R&D and its financial performance was proven to be positively correlated (Hyoungsuk & Hyungjun, 2020). A company that invests much in intangibles to create a new product or service makes more money if the invention is broadly adopted. (Pegah & Peter, 2018); (Tang & Jianping, 2021).

The aim of the study is to examine how intangible spending is distributed and diversified, especially in public sector organizations, while taking firm-specific factors like size, profitability, and corporate governance procedures into account. By studying the risks and rewards of various R&D expenditure patterns in emerging countries and comparing best practices from Navaratna businesses, the study intends to investigate how decision-making units (DMUs) might enhance managerial choices in intangible investments.

The crucial question is that how can the managerial decisions be improve in allocating intangibles investments and the direction and control of various decision variables with regard to best practise benchmarking . The argument put out in this study is that a decision-making unit (DMU) should take into account an element or set of elements as a decision value driver when a set of multiple performance measurements reveals that one or more aspects are important for upholding and reaching the best practise. Navaratna categorized enterprise. To consider the measure of specific company efficiency in each DMU, we define weighted measure-specific scores by taking into account the company sizes.

Literature Review:

- This study focus the findings of the critical evaluation of the evaluated literature that are more pertinent to the important issues and to provide answers to them, using the eligibility criteria for each dimension as a framework of includes. Research findings from various studies are organized and documented according to outcome measures in order to obtain a new viewpoint on the problems. Since their innovation systems are still in their infancy, many developing countries still lack the knowledge required to facilitate the creation of resources that can be used economically.(Sutz, 2000). Some aspects of intangibles increase productivity, while others do not, according to a study on banks' investments in intellectual capital to boost output.(Godfred & Pattanayak, 2019).
- In research and development decisions in the R&D investment model when analyzing firms' engagement in research as compared to development activities, it predicts higher spending in both activities for larger firms, but it also found that research intensity decline with firm size(Annette & Anwasha, 2022). It is found that agency costs experience therefore, agency expenses are reduced at both low and high business size and R&D activity levels. Firm size and R&D activity have a maximum value in this instance. (Giorgio & Stephen, 2022).
- This study is about corporate practices on intangible investments in enhancing productive capability, both in software expenditure (competitive profit efficiency) and other R&D spending (expansive productive efficiency) dimensions. The objective of this study is specifically focus on the diverse pattern of Software and other R&D spending on both enduring and expansion capabilities with the revenue, and net value added considering the various types of decision-making challenges that the Navaratna PSEs are now operational to improve and verify for uniformity in the spending pattern and productive performance ranking between the enterprises under study through the DEA-Sensitivity score. There are six variables our of which four variables are input namely material consumption, employee expenditure, spending on software, spending on other R&D and output varials are returns and net value added.
- The findings show that different businesses have different multifaceted financial performance and intangible expenditure efficiency. Efficiency is correlated with corporate size, particularly for companies such as ONGC, BHEL, and GALE, and larger enterprises with higher intangible spending may not always perform better than smaller ones.
- Taking into account the conceptual framework, the objective of the research, and the requirement to support the research question as emphasised above from the theoretical propositions the following hypothesis is considered:
- H0: With a set of multiple decision variables, there emerges no uniformity in the performance grades between the Navaratna Enterprises under study, and the Enterprises do not minimize the risk of diverse spending patterns on intangibles in achieving the best practice score with the changes in the value of sizes of the companies.
- HA: With a set of multiple decision variables, there emerges uniformity in the performance grades between the Navaratna Enterprises under study, and the Enterprises do minimize the risk of diverse spending patterns on intangibles while using the modifications to achieve the best practise score in the value of sizes of the companies.
- This analysis is consistent with previous research that uses firm-level data to examine how several intangible spending factors, including firm size, affect performance.

Theoretical Framework

- This research revolves around exploring the different spending patterns affect intangible investments—more especially, software expenditure and other R&D spending—and how this affects Navaratna Public Sector Enterprises' (PSEs') performance and capacity for productivity. The purpose of the study is to ascertain whether spending trends are consistent and how they impact these businesses' performance and efficiency.
- Provides an overview of the general subject of intangible spending and how it relates to business performance. Highlight variety of accounting-related developments and discussions around intangible investments. Provides an overview of previous studies on intangible spending and how it affects corporate governance, innovation, R&D, and business success. Talks about how many factors affect R&D investment and corporate performance, as well as the role of intangibles in emerging economies.
- Describes the study's goals for examining software and R&D spending trends and how they affect the performance of Navaratna businesses. Draws attention to the need of researching these trends and how they affect corporate decision-making. Formulate research questions on how spending habits affect intangibles and how performance grades are consistent. Proposes hypotheses concerning the relationships between spending patterns, firm size, and achieving best practice scores.
- Describes the approach for data collection and analysis, focusing on input variables like material consumption, employee expenditure, software costs, and R&D spending. Outlines the DEA (Data Envelopment Analysis) methodology used to evaluate efficiency scores and categorize decision-making units.
- Presents the efficiency scores of Navaratna enterprises based on spending on software, R&D, and other factors. Discusses how different spending patterns influence efficiency and performance in these enterprises.

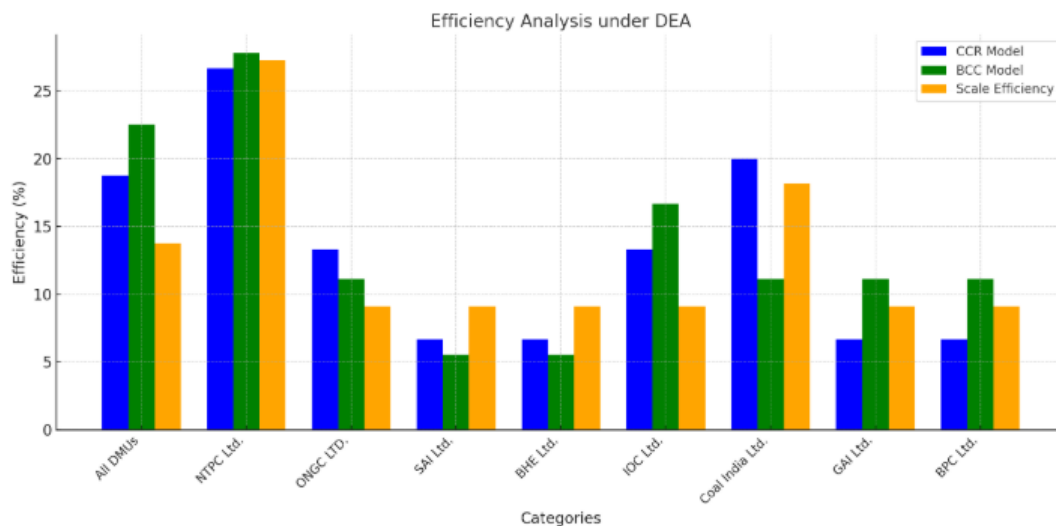


Fig:1 Trend of R&D spending in CRR, BCC Model and Scale Efficiency under Data envelopment analysis (DEA).

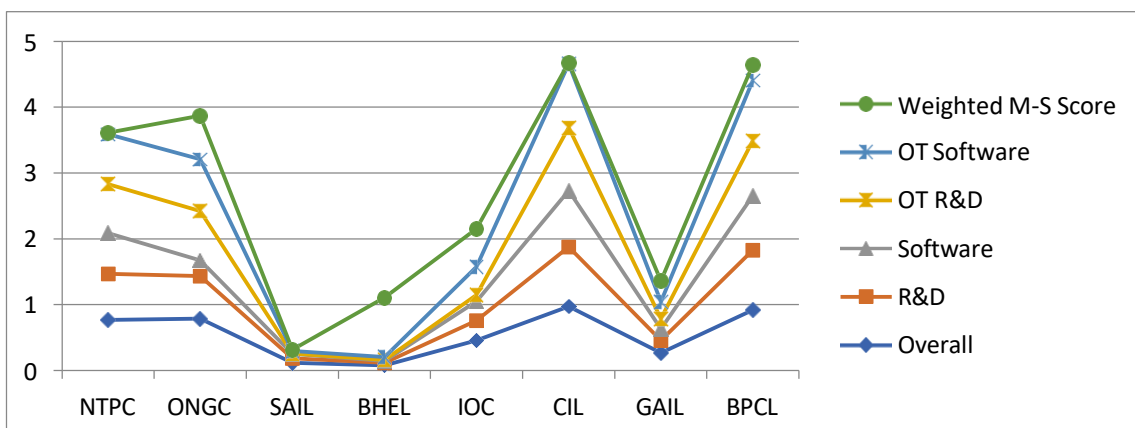


Fig:2 Efficiency Scores of NAVARATNA Enterprises under VRS.

Methodology:

Methodology refers to The methodical technique utilized to conduct research and gather relevant information in order to analysis test hypotheses or research questions. It involves selecting appropriate research methods, designing the study, collecting and analyzing data, and drawing conclusions based on the findings.

Research Design:

Research design is the overall plan or structure that guides the research process. The research design ensures that the study is conducted systematically and provides a framework for obtaining valid and reliable. This study framed an efficiency score by collecting secondary data (2013-14 to 2022-23).

Method:

Research method refers to the specific approach or technique used to analyze data in a research study. The presents research data are collecting from Public Enterprise Survey Report issued by the Department of Public Enterprise of Government of India.

Data Collection:

Research data collection involves to the relevant information or data to address research objectives. In this study all the data are secondary sources and collect from Public Enterprise Survey Report.

Data Analysis strategy:

Data analysis strategy is the planned approach for processing and interpreting collected data. It involves selecting appropriate statistical techniques or qualitative methods, organizing and cleaning the data, performing calculations or coding, and deriving meaningful insights or conclusions to address the research objectives or research questions. In this study, Data Envelopment Analysis (DEA), a non-parametric method is used to evaluate the relative efficiency of multiple decision-making units (DMUs). It compares the performance of DMUs that generate numerous outputs by consuming various inputs. DEA determines the efficiency scores by assessing how efficiently each DMU utilizes its inputs to generate outputs, allowing for benchmarking and identification of best practices with the help of R Studio-software is used for analysis the efficiency score.

Variables:

The contribution of the deciding factor from the container of four inputs—software spending, other R&D expenditures, materials, and employee—is examined in this study costsand returns for Navaratna Enterprises over the last 10 years, on a collection of profitable activities that include revenue and net value-added, since these are more consistent in increasing profit and production capacity when an input-oriented VRS is used., CCR, BCC and Scale efficiency weighted measure-specific DEA model with the R software,.

Research validation:

To determine the key variable, the best practice status based on the business units is categorized using the four input variables: material consumption, staff expenditure, software spending, and spending on other R&D. To determine whether a change in a key element's value significantly alters the performance grade between the units under examination, the efficiency score is analyzed. It then evaluated the score using the DMU size as an intervening variable from the unit's published data for the previous 10 years. For a specific inefficient model, the VRS measures DMU_d ,

$$\begin{aligned} \theta_d^{k*} &= \min \theta_d^k \quad d \in N \\ \text{Subject to} \\ \sum_{j \in E} \lambda_j^d x_{kj} &= \theta_d^k x_{kd} \quad k \in \{1, \dots, m\} \\ \sum_{j \in E} \lambda_j^d x_{ij} &\leq x_{id} \quad i \neq k \\ \sum_{j \in E} \lambda_j^d y_{rj} &\geq y_{rd} \quad r = 1, \dots, s \\ \sum_{j \in E} \lambda_j^d &= 1 \\ \lambda_j^d &\geq 0, j \in E, \end{aligned} \quad (1)$$

Where E indicates the index sets for the efficient and inefficient companies respectively and is identified by the VRS envelopment DEA model. It determines the maximum potential decrease of input while keeping other inputs at the current level. We define weighted measure specific scores within each company by

considering the sizes of the companies with the net worth as a proxy of the size. We define k th input-specific benchmark-share for each efficient $DMU_j, j \in E$,
 $\lambda_j^k = \{\sum_{d \in N} \lambda_d^k (1 - \theta_d^k) x_{kd}\} / \{(1 - \theta_d^k) x_{kd}\}$
 Where λ_j^k and θ_d^k are optimal values in (1) above.

Result:

The baseline DEA model demonstrated significance efficiency and strong discrimination amongst DMUs. Similar features could not be replicated by variables associated with inventive activity in another model. The CCR model's average efficiency went up a little. However, the BCC model did not adequately distinguish between efficient and inefficient units, misclassifying a larger percentage of DMUs as efficient. Interestingly, the BCC model's efficient unit percentage increase sharply from 21.25% in the base case to 56–60%.

Table 1 Results obtained Charnes–Cooper–Rhodes (CRR) model , Banker–Charnes–Cooper (BCC) Model and Scale Efficiency under Data envelopment analysis (DEA)

	CCR model		BCC model		Scale efficiency	
	Efficient DMU	% total	Efficient DMU	% total	Efficient DMU	% total
All DMUs	15	18.75	18	22.50	11	13.75
NTPC Ltd.	4	26.67	5	27.78	3	27.27
ONGC LTD.	2	13.33	2	11.11	1	9.09
SAI Ltd.	1	6.67	1	5.56	1	9.09
BHE Ltd.	1	6.67	1	5.56	1	9.09
IOC Ltd.	2	13.33	3	16.67	1	9.09
Coal India Ltd.	3	20.00	2	11.11	2	18.18
GAI Ltd.	1	6.67	2	11.11	1	9.09
BPC Ltd.	1	6.67	2	11.11	1	9.09
Average efficiency (%)		69.56		73.91		94.33
Standard deviation		17.71		17.93		8.28

The efficiency metrics for our basic DEA model are showing in Table 1. The CCR and BCC models consistent maintaining an average technical efficiency of about 70%. However, scale efficiency increases to greater degrees. The efficiency percentage for all units varies between 13.75% and 21.25%, depending on whether the model is BCC or CCR. It's interesting to note that NTPC Limited's scale efficiency exceeds its technical efficiency, indicating that inefficiencies stem from management and/or operations. However, Bharat Petroleum Corporation Limited's efficiency might be further increased by growing its operations. The DEA model results do not establish a significant performance among the enterprises are not uniform. Hence null hypothesis is rejected.

Table 2 Annexure-I Efficiency Scores of Navaratna Enterprises

As the drive is to identify the contribution of operating expenditure, spending on software, and other R&D investments to the performance grade, we selected a bundle of two variables namely revenue and net-value-added as the DEA outputs. A weighted measure specific VRS oriented efficiency scores of the operating unit depicts that only 11 percent of the total units are running at the best practice level and that efficiency may be highly correlated with size in these DMUs, otherwise there is no uniformity in the performance grades between the decision-making units under study. The input-oriented VRS efficiency scores' outcomes for NTPC exhibit that at least fifty percent of scenarios software and spending on R&D are the decisive value drivers. It appears that when other than R&D and software spending applied to each input measure separately, the input had no effect on the unit's efficiency classification because each related input may have been inefficient when other inputs were fixed at their current level.

It appears that when R&D and Software are applied for each input measure at a time, the R&D and Software expenditure input independently attained the efficiency classification in the last year of ONGC but the size-specific comparative efficiency score is optimal at the beginning and the fifth year of the study period. SAIL which is an inefficient unit, the optimal values are far from the best-practice frontiers, and it points out that spending on intangibles is not the decisive determinant in achieving the performance frontier. BHEL has the optimal solutions when the sizes of the units are reconsidered to characterize the efficiency. Similarly, IOC depicts an optimal solution during the last two years of the study period but when the size measure is into consideration it attained the optimal score in the initial year of the study period. CI is efficient under the envelopment model in almost all the years during the study period but size-specific scores yield different efficient targets so the unit cannot be considered as efficient since both measure-specific and envelopment models produce the same frontier, a DMU is efficient under envelopment models if and only if it is efficient under measure-specific models.

GAIL with an untenable average score of 0.26528 indicates possible inefficiency exists in each associated input when other inputs are prearranged, the VRS scores are scattered throughout the study period. When R&D and Software spending is exclusively applied for BPC it reaches the optimal solutions with a best-practice score during the first half of the study period. However, when the sizes of the units are specifically considered the model yielded different efficient targets indicating the possible inefficiency of the DMUs.

Discussion:

The DEA model effectively identified which DMUs performed better than others by demonstrating significant efficiency and good discrimination among them. These features, however, could not be reproduced when creative variables (including R&D and software spending) were included to a different model, indicating that not all variables have an equal impact on performance metrics. In the CCR model maintained an average technical efficiency of almost 70%, indicating a minor improvement in efficiency. On the other hand, the BCC model struggled to differentiate between units that were efficient and those that weren't. Its efficient unit percentage increased radically from 21.25% in the base case to 56-60%, and it incorrectly identified a sizable portion of DMUs as efficient (up to 60%). This change implies that the BCC model can miss more subtle differences in unit performance even though it is superior for scale efficiency. Technical efficiency constant across all models (about 70%), while scale efficiency varied more, with units showing efficiency percentages ranging from 13.75% to 21.25% depending on the model (BCC or CCR).

In this model, NTPC Limited's inefficiencies resulted from management and operations rather than technical performance because scale efficiency outperformed technical efficiency. As Bharat Petroleum Corporation notes that scale can occasionally trump management in influencing performance, it could increase efficiency by growing its activities. This study examined how R&D investments, software expenditures, and operations expenses affected performance. Notably, NTPC's R&D and software expenditures had a considerable impact on its efficiency scores; however, other inputs had no discernible impact on efficiency classifications when only one input was changed at a time. This implies that NTPC's success was significantly influenced by R&D and software investments. Different efficiency results were displayed by different units, such as SAIL and BHEL. BHEL outperformed SAIL in terms of unit size, although SAIL continued to be inefficient and far from the frontier of best practices. Similarly, IOC demonstrated size-based variability earlier in the trial period but functioned ideally over the last two years.

According to the investigation, efficiency was largely determined by size-specific performance, or the DMU's size. Certain units, such as CI and GAIL, showed effectiveness under envelope models but were unable to sustain steady performance when size was taken into account. According to the results, the multidimensional financial performances of the enterprises varied over the course of the study, and the efficiency of a small number of companies, such as ONGC, BHEL, and GALE, is strongly correlated with their size. Additionally, DMUs that spend more on intangibles do not necessarily perform better in terms of returns and net value added.

Conclusion:

In the DEA model's application effectively revealed performance variations across Decision-Making Units (DMUs), emphasizing their effectiveness and offering robust discrimination. R&D and software spending are examples of creative factors that were added to the model, but the results were inconsistent, indicating that they may not always have an impact on performance indicators. While the BCC model struggled to differentiate between efficient and inefficient units, particularly as its efficiency percentage for units increased sharply, misclassifying a significant number of DMUs as efficient, the CCR model maintained a steady technical efficiency of roughly 70%. This suggests that although the BCC approach would be more appropriate for evaluating scale efficiency, it might miss more subtle performance differences.

The findings show that scale efficiency outperformed technical efficiency and that operational and management issues were more responsible for inefficiencies in units like NTPC. The study also emphasized how crucial R&D and software spending are to increasing productivity, especially for NTPC, whose higher performance was largely due to these expenditures. The investigation also showed that larger units frequently performed better and that efficiency is frequently connected with unit size, as seen by the differing findings for several DMUs, including BHEL, SAIL, and IOC. However, since not all units benefited equally from such expenditures, the theory that increased spending on intangibles like R&D would result in better performance was disproved.

Limitation & Further study

The study is solely based on secondary data and it would have been different had it been able to incorporate the existing practices of their intangible spending decisions. The study has a scope to further research to extend the present research area by extending the sample size by incorporating Maharatna and Miniratna companies of the public sector enterprises. Studies can be made in this research area with a more extended study period. A comparative study can also be made with the tenure of the companies.

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Quality Educational Management: A Study on the Children of Daily Wage Workers' of West Bengal

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Abstract

India's educational development is a mixed bag of remarkable successes and glaring gaps. In the post-independence period, the pace of educational development was unprecedented by any standards. At the same time, perhaps, policy focus and public intervention in the provisioning of educational services were not adequately focused. There are critical gaps in the availability of infrastructural facilities and qualitative aspects of education, including teachers training, educational curricula, equipment and training materials, particularly, in the publicly funded schooling system of the country. The attainments and the failures have not been uniform across all regions. Though regional differences are indeed striking, there has been a significant reduction in inequalities in educational attainments across gender and population segments by income levels and the rural-urban divide. Illiteracy is a common phenomenon in our country, because people migrate from one place to another in search of different kinds of jobs. So, a lot of research has been made on the effects of education on their children. In India we have a large number of daily wage workers who migrate from one place to another in search of work. Studies have been made on different effects of education on the children of daily wage workers. This study was conducted in the Birbhum district of West Bengal. The sample consists of 300 students (children of daily labourers) school going and non – going of age group 6 -14 years. This study also includes 120 daily wage workers (MGNREGA).

Keywords: Educational, Government, Management, NGOs, Wage Workers

Introduction

Education is a merit good, and it is also considered a public good, producing huge set of externalities, internationally education particularly school and more particularly elementary education is recognized as a basic need. In the framework of Indian development planning, it is considered as one of the important minimum needs (Tilak, 2000). A common belief is that most Indian parents belonging to the low-income level are disinterested in their child's education. This belief is prevalent even with policy makers and experts on education, and is manifested in statements like illiterate and semi-literate parents see no reason to send their children to school, or the vast majority of adult illiterates belonging to the poor economic stratum are not convinced of it that literacy is a basic right of every education.

The study negates the view that daily wage workers (parents) reject the value of education. Respondents argued that education is important for both boys and girls. Thus, the 'value system' theory cannot be accepted as an explanation for low levels of education. The motivations underlying choice of education provide an indication of the valid explanation. The study also indicates that parents believe that 'education' is important as it helps an individual in his/her daily life.

In rural India, the socio-economic conditions have largely constrained the process of education and the social inequalities of caste, class and gender have been identified as the major causes of educational deprivation among children in India. A large proportion of children from the economically poor and socially disadvantaged groups, especially girls, are either denied access or are failing to complete even five years of basic education. The goal of universal and compulsory education remains a challenge to achieve even after decades of independence (Khan and Khan, 2013). The girl child not only in India but in most of the developing world is having the constraints of attaining satisfactory levels of schooling and regularity in their participation. The tendency among girls particularly belonging to the Scheduled Castes has been found to be low in their participation in education and this phenomenon of low participation, retention and irregularity in attending the schools (Panda, 2012). An illiterate person is that much less equipped to defend herself/himself in court, to obtain a bank loan, to enforce her inheritance right, to take advantage of new technology, to compete for secure employment, to get on the right bus, to take part in political activity, in short, to participate successfully in the modern economy and society. Similar things can be said about numeracy and other skills acquired in the process of basic education. Basic education is also a catalyst for social change (Dréze & Sen, 1995). The cultural factors may play an intermediate role, they influence the choices made by individuals, through their own attitudes, and those of the

people in their close environment. With respect to culture, India is part of a classical patriarchy that stretches from North Africa to China and includes both Muslim, Hindu and Confucian cultures. The cultural factors show that belonging to a disadvantaged caste or tribe is negatively associated with schooling. Girls belonging to a scheduled caste are less in school in rural areas and girls belonging to a scheduled tribe are less in school in urban areas. The odds of being in school are also significantly reduced for children whose mothers had their first child at a young age and for children whose mothers have a preference for boys over girls (**Sen, 1992**).

Parental Education and Economy

The strong effect of parental education on school enrolment, with father's education being more important for boys and mother's education more important for girls. Secondly, they find a clear "intrinsic disadvantage" among families of Scheduled Castes, Scheduled Tribes and Other Backward Castes though not Muslims. Among household characteristics, ownership of assets has a significant positive effect on enrolment (**Dréze & Kingdon 2001**). The probability of school enrolment depends on parental literacy. While the literacy of the male head of households affects positively both sons and daughters, a mother's literacy is seen to be more important for daughters. Among family characteristics, per capita expenditure and caste status had significant effects on enrolment and retention of children in school in rural West Bengal (**Kambhampati & Pal 2001**). Parental education and family income significantly increase the probability of children's school attendance and reduce the likelihood of children's participation in work. Mother's education exerts a much stronger effect of increasing school enrolment and reducing child labour. The maternal education more the likelihood of a girl child's school enrolment than boys and also reduces more the work participation of girls over boys. In cities schooling decisions are hardly influenced by supply-side factors. In rural areas, however, these factors do play an important role. If there are fewer schools or teachers, or if the local culture is more patriarchal, rural children (in particular girls) participate substantially less. In rural areas inequalities between socio-economic status groups are lower if more schools and teachers are available. Socio-economic indices like the characteristics of households, parental income, wealth, education and occupation, have long been known to be major determinants of educational enrolment and achievement in both developing and developed countries (**Huisman & Smits, 2010**). Poverty and the Demand for Schooling mentions that poverty is often assumed to be the main reason why any Indian parents don't send their children to school. One version of this story, which is particularly popular in official circles, is that poor parents cannot afford to send their children to school because their labour market makes a crucial contribution to the household economy. Literacy rates and school attendance certainly go down as one considers progressively poorer sections of the population. The problem of low average literacy rates is compounded by large inequalities, reflected in abysmally low literacy rates for the most disadvantaged sections of the population. Scheduled-caste women, for instance remain almost entirely illiterate in a majority of the district. The caste-based differences in educational achievements are statistically significant even after controlling for differences in income levels (**Dréze & Gazdar, 1997**). The reason for so many children not being in school had less to do with their families economic circumstances than with the school system's short comings. The inadequacy of the school system to attract and keep children is more crucial than households' economic conditions. School enrolment has risen dramatically in cities and villages, but the ability of the government's school system to retain and adequately educate children has been less impressive. (**Banerji, 2000**)

Literature Review

As per study done by (Kamtabli 2021) study explains that in India highlighting its challenges and opportunities in higher education system is the third largest globally but faces issues like low gross enrolment ratio equity, equality infrastructure faculties' shortage and inadequate result. In contrast to wealthy nations, it displays a low gross enrolment ratio. The Indian educational system has to be updated. Both the syllabus's words and the pedagogy utilized to instruct students should be updated. While theoretical knowledge is vital, what matters most is its practical application (Kashikar 2022).

Teachers with more experience and greater resources are found in private schools. Public schools include minimum amenities, a large structure, and trained staff. There is no discernible difference in elementary school student achievement between private and public schools, and government schools place a higher priority on oversight and monitoring. Additionally, it demonstrates how crucial high-quality education is to economic growth (Chaprana 2024).

As per study done by (Jatawa 2020) study shows the significant growth in private and government schools (2014-2018) towards high dropout rates, particularly among girls in Bihar, Rajasthan and Uttar Pradesh. Disparity between disadvantaged and privileged populations is necessary for the development of infrastructure and high-quality teacher training. Social and economic factors influence school choices, private schools have better infrastructure and resources, their teachers are more qualified, their student performance is higher, and their teacher-to-student ratios are lower than those of private schools (Agrawal and Pathani 2021). Teachers at government schools are paid more than those in private schools. Instructors in government schools feel more secure and content with their jobs than those in private schools, although private instructors take less leave than

government teachers (Akhtar 2013). Issues including inadequate classrooms, cleanliness, and technology are brought to light by government schools' substandard infrastructure. Student learning is impacted by poor infrastructure, and school management initiatives fall short because of the lack of resources required for efficient financial usage (Surti et al., 2024).

According to a research by Mandal (2024), 60% of respondents cited economic issues as the primary cause of dropouts, indicating that lack of family motivation, inadequate infrastructure, and financial restraints were important contributing factors. He came to the conclusion that lowering dropout rates requires tackling these socioeconomic problems, enhancing educational facilities, and successfully putting government regulations into practice. Relationships between socioeconomic circumstances, school accessibility, a child's desire in learning, and parents' opinions toward equitable education and school dropout rates (Sarkar 2017). High dropout rates are largely caused by socioeconomic problems, poverty, inadequate school infrastructure, and underqualified teachers (Moulick et al., 2024). Enrolment, dropout, and retention rates are greatly influenced by elements including social participation, parental perspective, infrastructure, family involvement, and quality teachers (Biswas and Singh 2022).

Objectives of the study

- To know perceptions of the parents/ daily wage workers (MGNREGA) about the relevance of education to their children and about the environment, infrastructural facilities and expansion of education in district?
- To find schooling experiences/perceptions of students and of those who have discontinued their education with reference to family, school and future educational expectations?

Research questions

- What are the perceptions of the parents/ daily wage workers (MGNREGA) about the relevance of education to their children and about the environment, infrastructural facilities and expansion of education in district?
- What are the schooling experiences/perceptions of students and of those who have discontinued their education with reference to family, school and future educational expectations?

Methodology

The study has been conducted using mixed method. For the data collection the researcher has applied the survey method. A tool was constructed to collect the data. Before applying the tool, it was standardized. To check the reliability and validity of the items, a pilot study was conducted before the survey. A survey was conducted in Birbhum district of West Bengal on 300 students of age group 6 – 14 years and 120 parents. The study was based on parents' concerns about their children's primary education and students' responses to their primary education.

Logistic regression

Logistic regression analysis is used to identify the relationship between dependent variables and independent variables. The logistic regression model is shown as following form

$$\ln(P / 1 - P) = \beta_0 + \beta_1 x_i$$

logit (P) is the log (to base e) of the odds ratio or likelihood ratio and the dependent variable is 1.

In symbol it is defined as

$$\begin{aligned} \text{logit (P)} &= \log [P / (1 - P)] \\ &= \ln [P / (1 - P)] \end{aligned}$$

Where P can only range from 0 to 1, logit (P) scale ranges from negative infinity to positive infinity and is symmetrical around the logit of .5 (which is zero). Formula below shows, the relationship between usual regression equation ($a + bx$ etc.)

Which is a straight line formula, and the logistic regression equation is

$$\text{logit } [P(x)] = \log [P(x) / 1 - P(x)] = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots$$

P can be calculated with the following formula

$$P = \exp(a + b_1x_1 + b_2x_2 + b_3x_3 + \dots) / 1 + \exp(a + b_1x_1 + b_2x_2 + b_3x_3 + \dots)$$

Where P = the probability that a case is in a particular category

exp = the base of natural logarithms (approx ...2.73)

a = the constant of the equation and

b = the coefficient of the predictor variables

Table:1 Regression Analysis in the final model showing the effect of encouragement from Govt./NGO to the expansion of education in the district and the education may bring better future to their children

Encouragement from Govt./NGO		B	Std. Error	Wald	df	Sig.	Exp(B)
Very satisfactory	Intercept	6.784	1.377	24.290	1	.000	
	expansion	-1.045	.255	16.851	1	.000	.352
	better	-1.756	.437	16.149	1	.000	.173
Pretty satisfactory	Intercept	4.589	1.373	11.169	1	.001	
	expansion	-.747	.265	7.976	1	.005	.474
	better	-1.281	.387	10.929	1	.001	.278

The reference category is: Not too satisfactory

N= 120 (Very satisfactory = 42, Pretty satisfactory = 54, Not too satisfactory =24). Model chi-square = 65.006, $p < 0.01$, -2 log likelihood = 43.552, Pseudo R-Square (Nagelkerke) = .477

These are the estimated multinomial logistic regression coefficients for the models. An important feature of the multinomial logit model is that it estimates K-1 models, where K is the number of levels of the outcome variable. In this instance, SPSS is treating the not too satisfactory as the referent group. Therefore, estimated model for very satisfactory related to not too satisfactory and pretty satisfactory related to not too satisfactory. Therefore, the parameter estimates are related to the referent group, the standard interpretation of the multinomial logit, is that for a unit changes in the predictor variables, the logit of outcome related to the referent group is expected to change by its respective parameter (which is in log – odds units) given the variables in the model are held constant.

Table: 2 A Result of Regression Analysis on encouragement from Govt./NGO to the expansion of education

	Very Satisfactory	Pretty Satisfactory
Expansion	-1.045*** (.26)	-.747*** (.27)
Better	-1.756** (.44)	-1.281** (.38)

Note: (*) = Not significant

(**) = Significant at $p < .05$ level

(***)= Significant at $p < .01$ level

Using the district's educational expansion as a predictor, a multinomial logistic regression analysis is performed to predict 120 daily wage workers' perceptions of government or non-governmental organization support for their children's education and their belief that education could lead to a better future for their children. The overall fit of our model is substantial, as indicated by the model chi-square of 65.006 and p -value < 0.01 . Our data is modestly fitted by the Nagelkerke R^2 of .477, and the model explains 47.7% of the variance. Two predictors significantly contributed to the prediction, as shown by the Wald criteria ($p = .05$). The odds ratio/Exp.(B) indicates whether the odds are more or less likely to rise or fall in connection to the daily wage worker's assessment of government or non-governmental organization support for children's education, with one unit increase being more or less likely.

Expected Probability

A selection of these estimations are shown in the Probability of Encouragement from the Government/NGOs with corresponding predictions computed from the aforesaid regression model (Table 2). It offers both the lowest and the highest likelihood of government or non-governmental organization support for children's education. All of the explanatory factors included in the analysis were taken into account in the final model for predicting encouragement from the government and non-governmental organizations. The expansion of education in the district and the possibility that education will improve their children's futures are the explanatory factors for the government's and non-governmental organizations' encouragement of children's education.

The district's educational expansion was found to be a marginally better indicator of government and non-governmental organization encouragement for education than the possibility that education would improve their children's futures.

Regarding the explanatory variable, the district's educational expansion is enhanced by one unit; the likelihood that the variable, government/non-profit encouragement, will be less than satisfactory is greatly reduced.

Similarly, if we increase the explanatory variable by one unit, the likelihood that their children will have a better life in the future is likely to decrease. This means that the predictors for the encouragement from the government and non-governmental organizations are more likely to be very satisfactory or pretty satisfactory. Approximately 72.5% of the forecasts came true.

Interpretation

Overall, logistic regression analysis reveals that the primary reason students are unable to attend class on a regular basis is that they have no one at home to encourage them to do well in school. Most of the time, the family members are either illiterate or lack the understanding to be of assistance in alleviating the challenges that a youngster is facing. It demonstrates that both the district's educational growth and the potential benefits of education for their children's futures are important factors.05 and.01 levels with the elements that support government and non-governmental organization support for education (very satisfactory, pretty satisfactory). Children's lack of enthusiasm in their education and their involvement in household chores, especially for girls, are some of the distracting issues. Nearly the same proportion of responders to our survey concerning the district's current educational system believed it was irrelevant. Regular instruction, consistent instructor attendance, a larger class size, and improved school discipline were among the recommendations made.

Table 3. Regression Analysis in the final model showing the effect of family members tell to go to school to the using guidance from the parents concerning studies, to feel that education may provide better life in future, encouragement from the teachers to get educated and to feel importance of education in their life.

Family members tell to go to school		B	Std. Error	Wald	df	Sig.	Exp(B)
High priority	Intercept	8.640	1.375	39.487	1	.000	
	importance	-.976	.306	10.188	1	.001	.377
	future	-2.346	.469	25.079	1	.000	.096
	guidance	-1.446	.605	5.718	1	.017	.235
Medium priority	Intercept	5.467	1.358	16.198	1	.000	
	importance	-.615	.252	5.947	1	.015	.541
	future	-2.021	.487	17.256	1	.000	.132
Low priority	Intercept	9.932	1.269	61.248	1	.000	
	importance	-1.480	.300	24.399	1	.000	.228
	future	-2.425	.428	32.084	1	.000	.088
	guidance	-.961	.487	3.896	1	.048	.383

The reference category is: Never.

N= 300 (High priority = 41, Medium priority = 23, Low priority =133, Never =103). Model chi-square = 285.056, $p < 0.01$, -2 log likelihood = 124.403, Pseudo R-Square (Nagelkerke) = .675

These are the estimated multinomial logistic regression coefficients for the models. An important feature of the multinomial logit model is that it estimates K-1 models, where K is the number of levels of the outcome variable. In this instance, SPSS is treating the never as the referent group, therefore estimated model for high priority related to never, Medium priority related to never and low priority related to never. Therefore, the parameter estimates are related to the referent group, the standard interpretation of the multinomial logit, is that for a unit changes in the predictor variables, the logit of outcome related to the referent group is expected to change by its respective parameter (which is in log – odds units) given the variables in the model are held constant.

Table 4. A Result of Regression Analysis on family members tell to go to school

	High priority	Medium priority	Low priority
Importance	-.976** (.31)	-.615** (.25)	-1.480*** (.30)
Future	-2.346*** (.47)	-2.021*** (.49)	-2.425*** (.43)
Guidance	-1.446** (.61)	-.246* (.56)	-.961** (.48)

Note: (*) = Not significant

(**) = Significant at $p < .05$ level

(***)= Significant at $p < .01$ level

Using parental guidance regarding studies, the belief that education may lead to a better life in the future, teacher encouragement to pursue education, and the sense of importance of education in their lives as predictors, a multinomial logistic regression analysis is conducted to predict the children's perception of the family members' encouragement to send 300 children between the ages of 6 and 14 to school. With a p -value < 0.01 and a model chi – square of 285.056, our model as a whole fits quite well. Our data is modestly fitted by the Nagelkerke R^2 of .675, and the model explains 67.5% of the variance. According to the Wald criterion, each of the four predictors significantly influenced the outcome ($p = .05$). For every unit increment, the odds ratio/Exp.(B) indicates whether the odds are higher or lower in relation to the children's assessment of the likelihood that family members will tell them to go to school.

Expected Probability

The aforementioned regression model was used to calculate the probability that family members would be instructed to attend school with the corresponding predictors. A selection of these estimations is shown in Table 4. It offers both the lowest and the largest likelihood that family members will advise their children to attend school. All of the explanatory factors included in the analysis were taken into account in the final model for predicting whether family members would be instructed to attend school.

Teachers' advice, the possibility of a brighter future, and the value of education in their lives are the explanatory factors for why family members encourage their children to attend school. Education has emerged as the most significant predictor of family members' encouragement to attend school, followed by the value of education in life and teacher guidance. Education may lead to a brighter future. In terms of the explanatory variable, education may lead to a better future.

If the likelihood that the variable family will tell their children to attend school increases by one unit, it indicates that they will place a higher premium on sending them to school. In a similar vein, the likelihood that family members will advise their children to attend school is more likely to decline when we increase the explanatory variables of the value of education in life and teacher guidance by one unit. The correct prediction rate was about 72.2 %.

Interpretation

Overall, logistic regression analysis shows that all of the explanatory variables included in the analysis were taken into account when predicting whether family members would tell their children to attend to school. Family members' encouragement to attend school was found to be the most significant predictor of a brighter future, followed by the value of education in life and teacher guidance. It demonstrates that the factors of parental guidance on education, the belief that education could lead to a better life in the future, and the encouragement of instructors to pursue education and to recognize the value of education in their lives are all significant. .05 levels and .01 levels with the variables (high priority, medium priority, low priority) that the family members tell you to go to school. Since it aids in children's effective completion of their schooling, primary education is important. It helps the youngster comprehend a variety of topics and lays the groundwork for overall development. Children at this age should be encouraged to engage with one another and with nature in order to cultivate a positive attitude. Education must be thoughtfully planned to support children's healthy development. In early childhood care and education, parents are crucial. Parental participation is correlated with children's overall learning, and higher levels of parental involvement in their education have a good impact on academic attainment and school performance.

Discussion

The study's investigates the Educational Status of the children of daily wage worker in Birbhum districts of West Bengal. According to Wahl and Blackhurst's (2000) research, children are aware of career information from an early age, and as they advance in school, they become more interested in and knowledgeable about job concepts. According to a study by Bashir and Peerzada (2023), students' educational objectives did not alter substantially depending on their subject stream or home background. Research on cross-regional comparisons, long term outcomes, and the usefulness of supportive policies in practice is still lacking. Furthermore, because the roles that financial literacy, mentoring, and economic empowerment play in influencing students' educational trajectories are rarely considered, there are significant gaps in our understanding of the whole spectrum of opportunities and challenges faced by students in higher education. Pal's (2024) research serves as an example, detailing the progress, challenges, and prospects across many states and socioeconomic contexts. Although there have been improvements in healthcare, education, and economic involvement, political representation disparities still exist. A positive school climate and parental support are important indicators of students' educational goals. Idris et al. (2020) found that mothers and fathers who have received a strong education have a positive impact on their children's academic development. In addition to serving as mentors

and role models, parents with higher levels of education also provide their kids with the tools and resources they need to seek college or graduate degrees.

According to a study by Gupta and Basir (2017), parents' encouragement and support have a significant impact on their kids' educational experiences. A student's motivation, academic achievement, and educational objectives are all positively impacted by parental support. Additionally, the study by Das et al. (2022) finds that rural moms are more supportive of their children's education than rural fathers. According to Chingtham and Guite's (2017) research, all parents wanted to send their kids to school but were unable to do so because of financial constraints. The majority of their parents urged them to enrol in colleges or universities. The main causes of children's school dropouts were financial hardships, marriage, and religious constraints. It is well known that early marriages, illiterate parents, poverty, and a lack of knowledge or incentives all impede schooling. In their study, Mir and Lone (2023) find that the kids' female parents were housewives and their male parents were labourers. Parents still support their children's education in spite of this.

Conclusion

In the past, West Bengal was the educational leader in India. West Bengal was home to renowned academics like Nobel Laureates Amartya Sen and Rabindranath Tagore, as well as renowned universities like Visva-Bharati. However, given the complete failure of the current educational system, such accolades are no longer worthy of being trumpeted. In particular, children are deprived of their future since its basic education system is in shattered ruins. Massive absenteeism rates, a severe shortage of qualified teachers, impossible-to-complete assignments, the practice of private tuition, and the dilapidated and outdated infrastructure of primary schools are just a few of the problems that seem to plague the primary education system. These concerns are essential to India's future. If millions of ostensibly free and equal citizens are trapped in poverty due to a lack of education, the strong economic growth India has recently experienced cannot be sustained, and the stability of the Indian state cannot be guaranteed. Our nation has become one of the world's growing nations as a result of the rise in several areas during the 21st century. Although the government and non-governmental organizations have made several attempts, the literacy rate has grown when compared to a few decades ago; yet, the goal of 100% literacy has not yet been reached. The underprivileged community continues to have a low literacy rate. Nearly all eligible students benefit from the many incentives that the government offers in the schools that they oversee, and all parents are completely aware of these programs. Since the government's efforts have so far been beneficial, it is fairly possible to close the few holes that have lately been discovered with the aid of some of the above-mentioned policy measures that are easy to implement.

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Influence of News and Different Hacking Events on Bitcoin and Ethereum using Garch Models

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Abstract

Millions of bitcoins were stolen during August 2018 to September 2023. The societal impact of criminal activity in the cryptocurrency market is exemplified by the fact that with the average Bitcoin price standing at \$7,572 in 2018, the monetary losses amounted to a substantial \$8.9 billion. This study underscores the substantial impact of hacking events on cryptocurrency returns, notably highlighting the pronounced influence on Bitcoin. The study tested that there is a significant difference between the effect of good news and bad news on the point of bitcoin and Ethereum. Upon investigating how hacking incidents impact the uncertainty of Bitcoin and Ethereum returns. The findings of the study reveal two distinct responses following a hacking incident at day $t = 1$, there is an immediate increase in volatility. However, this heightened volatility is not a short-lived effect; it resurfaces once again at day $t + 3$. Moreover, there is also an effect of hacking incidents within Bitcoin and Ethereum market with a time lag of three days.

Keywords: Cryptocurrency, Bitcoin, Ethereum, Volatility.

Introduction

The rise of cryptocurrencies has illuminated a crucial concern. The implications of security breaches, notably the escalating instances of hacking. This study delves into the profound societal implications stemming from criminal activities within the cryptocurrency market. It aims to unravel the intricate relationship between these breaches and the consequential shifts in market dynamics, contextualized against transformative cryptocurrencies like Bitcoin and Ethereum, lauded for their decentralized and secure transactional frameworks. However, between August 2018 and September 2023, a notable surge in cyber-attacks underscored the urgent need to comprehend the profound impact of these breaches. This urgency becomes evident when considering the theft of substantial Bitcoin reserves, amounting to staggering financial losses estimated at approximately \$8.9 billion based on the average 2018 Bitcoin price of \$7,572. This context underscores the pressing necessity to thoroughly comprehend the multifaceted effects of hacking incidents on the cryptocurrency market. This research aims to precisely explore the nuanced repercussions stemming from both positive and negative news events concerning the valuation of Bitcoin and Ethereum. It endeavors to discern potential divergences in market dynamics between these leading cryptocurrencies. Additionally, it seeks to delve into the specific contributions of hacking events towards the uncertainty and volatility of returns for Bitcoin and Ethereum, placing a keen emphasis on understanding the temporal intricacies of market responses following such events.

Previous studies have typically highlighted immediate spikes in volatility post-security breaches. However, this study aspires to uncover any potential delayed or prolonged effects. Utilizing GARCH models, the research endeavors to precisely quantify the temporal impact of hacking events on the volatility of returns for Bitcoin and Ethereum. This nuanced understanding assumes pivotal importance in deciphering the underlying market dynamics and inherent risk factors within the continually evolving realm of digital assets.

The inception of cryptocurrencies marked a significant departure from traditional financial systems, introducing decentralized digital currencies powered by blockchain technology. Bitcoin, the trailblazing cryptocurrency that emerged in 2009, offered a decentralized system for peer-to-peer transactions secured by cryptographic protocols. Subsequently, Ethereum, introduced in 2015, expanded the capabilities of blockchain by enabling smart contracts and decentralized applications, further diversifying the cryptocurrency landscape. The inherent features of Bitcoin and Ethereum have positioned them at the forefront of the cryptocurrency revolution. Their decentralized nature, cryptographic security, and transparent transactional protocols have garnered widespread attention and investment interest, propelling them into the limelight of global financial markets. However, among their sudden rise, the cryptocurrency market has grappled with persistent challenges, notably security vulnerabilities. The period between August 2018 and September 2023 witnessed a distressing surge in cyber-attacks targeting cryptocurrency exchanges, wallets, and trading platforms. These breaches resulted in substantial financial losses, estimated at approximately \$8.9 billion in stolen Bitcoin reserves based on the average Bitcoin price in 2018. Such incidents underscored the vulnerability of digital assets to malicious activities and raised profound concerns about their security and stability within financial ecosystems. The

impact of these security breaches extended beyond financial losses, permeating societal and market dynamics. Investor confidence wavered, regulatory scrutiny intensified, and market volatility surged in the wake of these events. Understanding the nuanced effects of these incidents on the valuation and volatility of Bitcoin and Ethereum holds paramount significance in navigating the intricate landscape of cryptocurrency markets.

Moreover, the research aims to unravel the intricate relationship between hacking events and the volatility of returns for Bitcoin and Ethereum. Prior studies have often highlighted immediate spikes in market volatility post-security breaches. However, this study endeavors to comprehensively explore the temporal dimensions of market responses, aiming to uncover any delayed or prolonged effects stemming from these incidents. Leveraging GARCH models enables a granular examination of volatility patterns and temporal dynamics following hacking events, facilitating a nuanced understanding of the unique market reactions of Bitcoin and Ethereum.

T-GARCH and E-GARCH models used to check whether there is an impact of the incidents on the variables or not. T-GARCH tested that whether there is an impact of any news which can affect the returns- the coins of the cryptocurrency market in this study. The significant results of T- GARCH relates the impact of both the news (whether it is positive or negative) for the further proceedings to the E-GARCH model for calculating the overall impact of the news. This study noted the hacking events (negative news) in the cryptocurrency market for both the investors and the market by taking these days as a dummy for the further analysis.

Comprehending the temporal implications of hacking incidents on cryptocurrency market dynamics are essential in comprehensively assessing associated risks and uncertainties. While immediate volatility spikes may be evident, scrutinizing the prolonged effects and their duration becomes imperative to gauge the resilience and adaptability of Bitcoin and Ethereum within the evolving landscape of digital assets.

GARCH models, renowned for their efficacy in capturing volatility patterns and conditional variance in financial time series data, form the backbone of this research. By employing these sophisticated econometric tools, this study aims to quantify and analyze the temporal impacts of hacking events on the volatility of returns for Bitcoin and Ethereum. This detailed analysis will provide deeper insights into the temporal intricacies of market responses, aiding in comprehending the dynamic relationships between hacking incidents and cryptocurrency market dynamics.

Literature Review

The expanding realm of cryptocurrency has reaped a significant attention across various studies, each shedding light on distinct facets of this rapidly evolving landscape.

Manahov, V. (2024) noted a sudden and drastic downturn in the cryptocurrency market led to a sharp decline in 95 out of the top 100 digital currencies due to market crash in 2018. The behavior of the more prominent cryptocurrencies, particularly Bitcoin, was pivotal in triggering the market crash. Moreover, the smaller cryptocurrencies tended to follow the lead of their larger counterparts, exacerbating the downward spiral.

Yu-Lun, Chen. et.al (2023) analysed that cryptocurrency hacking is a significant issue that has been affecting the development and price dynamics of cryptocurrencies such as Bitcoin. Hacking incidents and the theft of funds have been found to decrease the returns and increase the volatility of bitcoin spot and futures.

Chawki, M. (2022) examined the link between cybercrime and cryptocurrency regulation. The study highlighted the challenges posed by cybercriminal activities in the realm of digital assets and suggests regulatory strategies to counter these issues. Additionally, it focused on the role of technological solutions in tracking illicit activities. By offering actionable recommendations, the study aims to bolster regulatory frameworks, creating a more secure environment while fostering responsible innovation in the cryptocurrency space.

Ferri (2022) found that hacking attacks have a significant and persistent impact on the volatility of cryptocurrency markets, but the impact varies depending on the size and reputation of the exchange that is hacked. Larger and more reputable exchanges tend to experience a smaller and less persistent impact on volatility.

Chawki (2022) discussed the relationship between cybercrime and cryptocurrencies, and the challenges that law enforcement and regulators face in addressing this issue. The author argues that a balanced approach is needed, focusing on targeting criminal activity while not stifling innovation in the cryptocurrency sector.

Grobys, K. (2021) discussed the vulnerabilities and uncertainties present in the cryptocurrency market, with a specific focus on the security of block chain technology and the occurrence of hacking incidents. It delves into the potential risks associated with these factors and their implications for the cryptocurrency market.

Corbet, S et.al. (2020) investigated the implications of cybercriminal involvement in cryptocurrency, emphasizing its potential to disrupt the economic landscape. The research delves into the destabilizing effects such activities may have on financial systems and their consequential impact on the broader economy.

Makarov and Schoar (2020) explored the dynamics of cryptocurrency prices and the existence of arbitrage opportunities in these markets. Additionally, it analysed the trading strategies utilized by market participants and the influence of these strategies on market efficiency. By providing insights into the functioning of cryptocurrency markets, this research sheds light on the significance of trading and arbitrage in these markets.

Kethineni and Cao (2020) investigated the growing popularity of cryptocurrency and its correlation with criminal activities. Different types of criminal behavior associated with cryptocurrency- money laundering, fraud, and illicit transactions are explored. Difficulties faced by law enforcement agencies when investigating and prosecuting cryptocurrency-related crimes. By providing valuable insights into the relationship between cryptocurrency and criminal activity, this study emphasizes the importance of implementing effective regulatory measures in this emerging field.

Twomey and Mann (2020) argued that cryptocurrency markets are particularly vulnerable to fraud and manipulation due to lack of regulation, anonymity, and complexity. They identify a number of specific types of fraud and manipulation that are common in these markets, including pump-and-dump schemes, wash trading, spoofing, hacking, and exit scams. The activities pose a significant threat to the integrity of cryptocurrency markets and call for greater regulation and investor education.

Mauro et.al (2018) examined Bitcoin's security and privacy aspects, different components, vulnerabilities, and existing solutions. It covered the system's structure, including block chain and the PoW consensus protocol, while highlighting potential security threats. Additionally, it assesses current security solutions, addresses anonymity concerns, and suggests future research directions for enhancing bitcoin's security and privacy measures.

Tony Klein (2018) found that bitcoin and gold possess distinct asset properties and relationships with equity markets. Unlike gold, Bitcoin exhibits an inverse correlation, rising when markets decline. Gold serves as a haven in financial turmoil, while bitcoin lacks consistent hedging qualities in portfolios. Bitcoin, as a part of the broader cryptocurrency index CRIX, doesn't offer stable hedging capabilities similar to Gold, apart from a unique response in variance during market fluctuations.

Katsiampa, P. (2017) examined the Bitcoin's volatility using different GARCH models with a comparative analysis to assess their performance in capturing the volatility of Bitcoin. The findings of this research offer valuable insights into the volatility dynamics of Bitcoin and shed light on the effectiveness of different GARCH models in accurately measuring its volatility.

Bouoiyour and Selmi (2016) delved into the potential of Bitcoin as a significant milestone in the evolution of digital currencies. The study thoroughly analyzed the characteristics and implications of Bitcoin, such as its decentralized nature, security features, and potential effects on traditional financial systems. The findings offer valuable insights into the opportunities and challenges that come with the adoption and development of Bitcoin as a novel form of currency.

David, Yermack (2014) observed the gold standard tied to convertibility that declined from 1920s to 1970s due to factors like financing wars and limited gold production. Fiat currencies, dependent on public trust in government or central bank control, emerged after this collapse in most major economies. Bitcoin aims to address the shortcomings of both gold-backed and fiat currencies by positioning itself as an "algorithmic currency" with a predictable supply and growth controlled by cryptographic rules.

This study builds upon the existing literature by examining the impact of hacking events on cryptocurrency returns, particularly focusing on Bitcoin and Ethereum. Previous research primarily highlighted the negative effects of hacking incidents on investor confidence and market stability (e.g., Böhme et al., 2015; Catalini & Gans, 2016). However, contrary to these findings, this study reveals a positive correlation between hacking events and cryptocurrency returns, suggesting that investors may view hacks as an opportunity to hedge against future risks by increasing their investments in Bitcoin and Ethereum. This finding extends the literature by presenting a different perspective on investors' behavior during security breaches, showing that such events may not always lead to market downturns. The results offer valuable insights into how market participants react to perceived risks and contribute to the understanding of short-term market dynamics in the cryptocurrency market.

Objectives of the Study

- To study the impact of hacking events on Cryptocurrency returns.
- To evaluate market flexibility and implications of hacking incidents.
- To assess the influence of market attitude and volatility on Cryptocurrency returns.

Data and Methodology

The research conducted is based solely on data obtained from secondary sources spanning the timeline from April 2019 to March 2024. The primary source of information regarding cryptocurrency coins is derived from Coinmarket.com, a reputable platform known for providing comprehensive data and insights into various cryptocurrencies' market performance. This data includes a wide array of information such as daily returns, trading volumes, market capitalization, and other relevant metrics associated with different cryptocurrencies during the specified period. For the aspect related to hacking events in the cryptocurrency domain, the data is sourced from chainsec.io/exchange-hacks, a platform specifically dedicated to documenting and cataloguing cryptocurrency exchange breaches or hacking incidents. Only incidents that have well-documented dates and precise information regarding the amounts compromised within the specified timeframe of the study are

incorporated into the analysis. The focus is on analyzing and including hacking events that occurred within the stipulated period, ensuring a thorough and precise examination of these occurrences and their potential impact on the cryptocurrency market.

The research methodology relies on the consolidation and rigorous examination of these datasets, carefully selecting and utilizing information that meets the study's criteria for accuracy, reliability, and relevance. By exclusively considering verified and well-documented hacking events alongside cryptocurrency market data from reputable sources, the study aims to provide a comprehensive and credible analysis of the relationship between hacking incidents and cryptocurrency returns within the specified timeframe.

Analysis and Interpretation

Table 1- Descriptive Statistics of Bitcoin Return with Hack and Hack+3 Days

	BTC_{RETURN}	BTC_{HACK DAY}	BTC_{H+3}
Mean	0.0015	0.0000	0.0002
Median	0.0008	0.0000	0.0000
Maximum	0.1722	0.0454	0.1603
Minimum	-0.4650	-0.1519	-0.1519
Std. Dev.	0.0358	0.0043	0.0075
Observations	1827	1827	1827

Source- Prepared by author in E-Views

BTC_{RETURN} shows daily Bitcoin returns whereas BTC_{HACK} and BTC_{H+3} show Bitcoin returns for hack day and 3 days after the hack respectively by taking hack as a dummy (1 if there was a hack on that day, 0 otherwise). The table interprets that Bitcoin returns have averaged 0.15% per day. The median of hacks is 0.0000 and the minimum of BTC_{HACK} is -0.1519 which indicates that there have been more days with no hacks than days with hacks. The largest daily Bitcoin return has been 17.22%. The maximum BTC_{HACK} is 0.0454, which means that there has only been one hack on a given day. The standard deviation of BTC_{RETURN} is 0.0358, indicating that Bitcoin returns have been very volatile. The standard deviation of BTC_{H+3} is 0.0075, which means that Bitcoin returns 3 days after a hack has been less volatile than daily Bitcoin returns. The standard deviation of BTC_{HACK} is 0.0043, which means that the number of hacks per day has been relatively stable. Overall, the table shows that Bitcoin returns are very volatile. This means that Bitcoin investors should expect large swings in both BTC_{HACK} and BTC_{H+3}

Table 2- Descriptive Statistics of Ethereum Return with Hack and Hack+3 Days

	ETH_{RETURN}	ETH_{HACK}	ETH_{H+3}
Mean	0.0017	0.0001	0.0002
Median	0.0012	0.0000	0.0000
Maximum	0.2307	0.0528	0.1449
Minimum	-0.5500	-0.1355	-0.1683
Std. Dev.	0.0451	0.0041	0.0082
Observations	1827	1827	1827

Source- Prepared by author in E-Views

Ethereum (ETH) exhibits notable volatility and unpredictability in its daily returns, portraying significant fluctuations within its market performance. On average, the daily return for Ethereum stands at 0.17%. However, the standard deviation, calculated at 0.0451, indicates a substantial likelihood of extreme returns, highlighting the inherent volatility within ETH's market behavior. This volatility suggests that Ethereum's value experiences significant shifts, making it susceptible to rapid and sizable price movements. The standard deviation of 0.0041 emphasizes the unpredictability of these events. Specifically, Ethereum tends to experience negative returns on the day of a hack and in the subsequent three days. The average return on the day of the hack is notably lower at -0.1683%, followed by an average return of -0.1355% in the three days following the hack. This consistent pattern suggests that hacking incidents significantly impact Ethereum's short-term performance, resulting in decreased returns immediately post-hack and persisting negativity for a short period thereafter. Overall, these findings underline Ethereum's susceptibility to extreme market movements, coupled with its vulnerability to the effects of hacking incidents. The negative impact of hacks on short-term returns indicates the market's sensitivity to such security breaches, emphasizing the need for vigilant monitoring and strategic measures to mitigate the adverse effects on Ethereum's value and investor confidence.

Table 3- Unit Root test for Bitcoin and Ethereum Returns

Unit Root Test		
Augmented Dickey-Fuller test statistic		
	t-statistic	Prob.
Bitcoin	-44.9670	0.0001
Ethereum	-45.6862	0.0001

Source- Prepared by author in E-Views

Both Bitcoin and Ethereum hold considerable significance at a statistical level. The t-statistics for Bitcoin and Ethereum, standing at -44.9670 and -45.6862 respectively, coupled with their low p-values of 0.0001, strongly reject the null hypothesis of a unit root within their time series data. This rejection indicates that both Bitcoin's and Ethereum's data exhibit stationarity, implying a lack of a unit root in their price movements. This absence of a unit root suggests that Bitcoin and Ethereum showcase more volatility and unpredictability compared to stationary time series data. Additionally, the findings imply that conventional technical analysis tools, which often rely on the assumption of stationarity, may not be as effective in accurately predicting future price movements for Bitcoin and Ethereum due to their non-stationary nature. Therefore, their distinct behavior challenges the efficacy of traditional analytical tools typically applied in financial markets.

Table 4 – List of Hacking Events

Date	Amount stolen	Exchange
01-04-2019	1,30,00,000	Bithumb
27-06-2019	42,00,000	Bittrue
12-07-2019	3,20,00,000	BITPoint
27-11-2019	4,90,00,000	Upbit
06-02-2020	73,000	Altsbit
08-09-2020	54,00,000	Eterbase
26-09-2020	28,00,00,000	KuCoin
01-02-2021	45,000	Cryptopia
19-08-2021	8,00,00,000	Liquid
05-12-2021	15,00,00,000	BitMart
11-12-2021	7,80,00,000	AscendEX
09-01-2022	68,00,000	LCX
01-11-2022	2,80,00,000	Deribit
10-04-2023	1,30,00,000	GDAC

Source- <https://chainsec.io/exchange-hacks>

To date, the cryptocurrency industry has experienced 55 significant hacking incidents, resulting in cumulative losses of approximately \$2.4 billion. The most devastating breach occurred in 2014, when Mt.Gox suffered a massive hack, leading to the theft of \$661,348,000, which remains the largest single loss. These security breaches have resulted in substantial financial losses, highlighting the ongoing challenges and vulnerabilities in the digital currency space. The table 4 catalogues 14 cryptocurrency exchange hacks spanning from 2019 to 2024, delineating the date, stolen amount, and targeted exchange. Notably, the majority of these substantial breaches have predominantly focused on exchanges based in Asia, likely attributed to the region's significant position as a cryptocurrency trading hub. The collective value pilfered in these hacking incidents surpasses a staggering \$1 billion. Among these breaches, the largest occurred during the KuCoin hack in September 2020, resulting in a staggering \$280 million theft, while the smallest breach transpired during the Cryptopia hack in February 2021, amounting to \$45,000 in losses. The table underscores a consistent rise in both the frequency and magnitude of cryptocurrency exchange hacks in recent years. This escalating trend is presumed to be a consequence of the surging popularity of cryptocurrencies coupled with the increasing valuation of digital assets. Cryptocurrency exchanges, being reservoirs of substantial digital wealth, become prime targets for hackers seeking unauthorized access. The fallout from a cryptocurrency exchange hack reverberates significantly for investors who bear the brunt of such incidents, facing the perilous loss of their digital assets. These breaches not only result in immediate financial losses but also inflict a substantial shock to investor confidence within the cryptocurrency industry, increasing the far-reaching impacts of these cybercrimes.

$$BTC_{RETURN} = \beta_0 + \beta_1 * BTC_{HACK} + \varepsilon \quad (1)$$

Where,

BTC_{RETURN} is the dependent variable (the return of Bitcoin)

BTC_{HACK} is the independent variable (a binary variable that is 1 if there was a Bitcoin hack on that day and 0 otherwise)

β_0 is the intercept

β_1 is the slope coefficient

ε is the error term

The equation represents a simple linear regression model used to examine the impact of Bitcoin hacking events (BTC_{HACK}) on Bitcoin returns (BTC_{RETURN}). BTC_{RETURN} serves as the dependent variable, indicating the return on Bitcoin, while BTC_{HACK} acts as the independent variable, taking a binary form (1 for a day with a Bitcoin hack and 0 otherwise). The coefficient β_1 quantifies the relationship between Bitcoin returns and hacking events, elucidating the change in returns associated with a unit change in BTC_{HACK} . The intercept β_0 signifies the expected Bitcoin return in the absence of hacking events. The model aims to understand how Bitcoin returns are influenced by the occurrence of Bitcoin hacks, offering insights into the potential impact of hacking incidents on Bitcoin's financial performance.

$$BTC_{RETURN} = \beta_0 + \beta_1 * BTC_{H+3} + \varepsilon \quad (2)$$

Where,

BTC_{RETURN} is the dependent variable (the return of Bitcoin)

BTC_{H+3} is the independent variable (a binary variable that is 1 if there was a Bitcoin hack in the past 3 days and 0 otherwise)

β_0 is the intercept

β_1 is the slope coefficient

ε is the error term

The equation provided represents a linear regression model aimed at examining the relationship between Bitcoin returns (BTC_{RETURN}) and the occurrence of Bitcoin hacks within a three-day window (BTC_{H+3}). BTC_{RETURN} stands as the dependent variable, representing the return on Bitcoin. BTC_{H+3} functions as the independent variable, taking on a binary form (1 if a Bitcoin hack occurred within the past three days, and 0 otherwise). The coefficient β_1 quantifies the impact of Bitcoin hacking events within this three-day period on Bitcoin returns, illustrating the change in returns associated with the presence of a recent hacking incident. The intercept β_0 signifies the expected Bitcoin return when there have been no hacking events in the past three days. This model seeks to elucidate how Bitcoin returns are influenced by the occurrence of Bitcoin hacks within this defined temporal window, providing insights into the potential short-term impact of recent hacking incidents on Bitcoin's financial performance.

Table 5 – Regression of Bitcoin Return with Hackings

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BTC_{RETURN}	0.0015	0.0008	1.7795	0.0753
BTC_{HACK}	0.9966	0.1951	5.1083	0.0000
Variable	Coefficient	Std. Error	t-Statistic	Prob.
BTC_{RETURN}	0.0013	0.0008	1.6021	0.1093
BTC_{H+3}	0.9951	0.1098	9.0644	0.0000

Source- Prepared by author in E-Views

The conducted regression analysis aimed to evaluate the effect of hacking events on Bitcoin returns. The model integrated dummy variables representing both the day of the hack and the subsequent three days following the event. The coefficients within the table interpret the influence of each variable on Bitcoin returns. For instance, the coefficient attributed to BTC_{Hack} stands at 0.9966, indicating that a Bitcoin hack event correlates with a noteworthy 0.9966 increase in Bitcoin returns. This impact holds significant statistical relevance, evident from the p-value of 0.0000. Conversely, the coefficient associated with Bitcoin Return (3 days after hack) is 0.0013, signifying that Bitcoin returns on the hack day slightly influence a mere 0.0013 increase in returns three days later. This influence lacks statistical significance, as indicated by the p-value of 0.1093. Collectively, the outcomes derived from the regression analysis suggest a positive impact of Bitcoin hacks on Bitcoin returns. The findings underscore the intricate relationship between hacking events and the market dynamics of Bitcoin, unveiling a notable shift in investor behavior in response to security vulnerabilities within the cryptocurrency landscape.

$$ETH_{RETURN} = \beta_0 + \beta_1 * ETH_{HACK} + \varepsilon \quad (3)$$

Where,

ETH_{RETURN} is the dependent variable (the return of Ethereum)

ETH_{HACK} is the independent

β_0 is the intercept

β_1 is the slope coefficient

ε is the error term

The equation presented represents a linear regression model investigating the relationship between Ethereum returns (ETH_{RETURN}) and the occurrence of Ethereum hacking events (ETH_{HACK}). In this context, ETH_{RETURN} serves as the dependent variable, signifying the return on Ethereum, while ETH_{HACK} operates as the independent variable, taking on a binary form (1 denoting the presence of a hacking event and 0 otherwise). The coefficient β_1 encapsulates the impact of Ethereum hacking incidents on Ethereum returns, depicting the change in returns associated with the occurrence of a hacking event. The intercept β_0 symbolizes the expected Ethereum return when there are no hacking events. This model aims to unveil how Ethereum returns are affected by the presence or absence of hacking incidents, providing insights into the potential influence of such events on Ethereum's financial performance.

$$ETH_{RETURN} = \beta_0 + \beta_1 * ETH_{H+3} + \varepsilon \quad (4)$$

Where,

ETH_{RETURN} is the dependent variable (the return of Ethereum)

ETH_{H+3} is the independent variable

β_0 is the intercept

β_1 is the slope coefficient

ε is the error term

The provided equation constitutes a linear regression model exploring the relationship between Ethereum returns (ETH_{RETURN}) and the occurrence of Ethereum hacking events within a three-day timeframe (ETH_{H+3}). In this context, ETH_{RETURN} signifies the dependent variable, representing the return on Ethereum, while ETH_{H+3} serves as the independent variable, taking a binary form (1 if a hacking event occurred within the past three days, and 0 otherwise). The coefficient β_1 characterizes the impact of Ethereum hacking events within this three-day period on Ethereum returns, highlighting the change in returns associated with recent hacking incidents. The intercept β_0 represents the anticipated Ethereum return when there have been no hacking events within the specified timeframe. This regression model seeks to unveil how Ethereum returns are influenced by the occurrence of recent hacking events, shedding light on the potential short-term impact of these incidents on Ethereum's financial performance.

Table 6 – Regression of Ethereum Return with Hackings

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ETH_{RETURN}	0.0017	0.0011	1.5859	0.1129
ETH_{HACK}	0.9946	0.2588	3.8434	0.0001
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ETH_{RETURN}	0.0015	0.0010	1.4612	0.1441
ETH_{H+3}	0.9954	0.1263	7.8785	0.0000

Source- Prepared by author in E-Views

A regression analysis was performed to examine the impact of hacking days on Ethereum returns. The model included dummy variables for the day of the hack and the three days following the hack. . The coefficient for ETH_{HACK} is 0.9946, which is statistically significant (p-value = 0.0001). This means that a hack event is associated with a 0.9946 increase in Ethereum returns on the day of the hack. The coefficient for ETH_{H+3} is also statistically significant (p-value = 0), meaning that a hack event is associated with a 0.9954 increase in Ethereum returns on the three days following the hack. Overall the results of the regression analysis show that both the day of the hack and the three days following the hack have a statistically significant impact on Ethereum price returns. In other words, hacking events can have a negative impact on Ethereum prices. This is likely because hacking events erode investor confidence in the security of the Ethereum network. In short, the table suggests that hacking events have a statistically significant negative impact on Ethereum price returns.

In a nutshell, both Bitcoin and Ethereum hacks have a positive and statistically significant impact on their respective cryptocurrency returns, both on the day of the hack and 3 days later. This suggests that investors seek to hedge their bets against future hacks by buying more Bitcoin and Ethereum after a hack. It is important to note that these are just observational studies, and they cannot prove that cryptocurrency hacks cause cryptocurrency prices to increase. However, the results do suggest that there is a strong correlation between cryptocurrency hacks and cryptocurrency price movements.

$$BTC_{RETURN_t} = \mu + \alpha(BTC_{RETURN_{t-1}}) + \beta(BTC_{RETURN_{t-2}}) + \varepsilon_t \quad (5)$$

$$\sigma^2_t = \omega + \alpha \varepsilon^2_t + \beta \sigma^2_{t-1} \quad (6)$$

Equation (5) is for the ARIMA and Equation (6) is for Garch Where,

BTC_{RETURN_t} is the Bitcoin return at time t

μ is the constant term

α is the AR(1) coefficient

β is the AR(2) coefficient

ε_t is the white noise error term, which is assumed to follow a Student's t-distribution with v degrees of freedom

σ_t^2 is the conditional variance of the Bitcoin return at time t

ω is the constant term in the GARCH equation

Equation (5) outlines an Autoregressive Integrated Moving Average (ARIMA) model that predicts Bitcoin returns at time ' t '. This model incorporates the Bitcoin returns from the previous two days, ' $t-1$ ' ($BTC_{RETURN,t-1}$) and ' $t-2$ ' ($BTC_{RETURN,t-2}$), denoted as α and β , respectively. Additionally, it includes a constant term (μ) and an error term (ε_t) following a Student's t-distribution with degrees of freedom (v). This predictive model aims to capture and utilize past returns to forecast the current return for Bitcoin, utilizing a combination of autoregressive and moving average components.

Equation (6) delineates a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model for the conditional variance (σ_t^2) of Bitcoin returns at time ' t '. This model incorporates a constant term (ω) and factors in the conditional variance based on the preceding variance (σ_{t-1}^2) and the squared error term derived from the ARIMA model. This GARCH model accounts for the volatility clustering observed in Bitcoin returns, acknowledging that past variances and squared errors impact the current volatility, thus illustrating how volatility tends to persist in the cryptocurrency's returns over time.

Table 7 – TGARCH on Bitcoin Returns

	Coefficient	Std. Error	z-Statistic	Prob.
BTC_{RETURN}	0.0015	0.0008	1.7761	0.0757
AR(2)	-0.0489	0.4106	-0.1190	0.9053
MA(2)	0.0929	0.4092	0.2271	0.8204
Variance Equation				
BTC_{RETURN}	0.0001	0.0000	9.0123	0.0000
RESID(-1)²	0.0837	0.0137	6.1256	0.0000
RESID(-1)²*(RESID(-1)<0)	0.1285	0.0137	9.3809	0.0000
GARCH(-1)	0.8022	0.0157	51.0269	0.0000

Source- Prepared by author in E-Views

The table shows the results of a GARCH(1,1) model fitted to the daily returns of Bitcoin. The coefficients in the ARIMA section of the table represent the impact of past Bitcoin returns (BTC_{RETURN}), second-order autocorrelation (AR(2)), and second-order moving average (MA(2)) on current Bitcoin returns. The coefficients in the GARCH section of the table represent the impact of past squared Bitcoin returns (BTC_{RETURN}^2), past volatility ($RESID(-1)^2$), and past leverage effect ($RESID(-1)^2*(RESID(-1)<0)$) on current volatility. The AR(2) and MA(2) coefficients are not significant, indicating that there is no evidence of second-order autocorrelation or moving average in Bitcoin returns. The $(BTC_{RETURN})^2$, $RESID(-1)^2$, and $RESID(-1)^2*(RESID(-1)<0)$ coefficients are all significant, indicating that past squared Bitcoin returns, past volatility, and the past leverage effect all have a positive impact on current volatility. The value 0.1285 indicates that any news rather it is bad or good, it can effect the prices of the Bitcoin returns.

$$ETH_{RETURN,t} = \mu + \alpha(ETH_{RETURN,t-1}) + \beta(ETH_{RETURN,t-2}) + \varepsilon_t \quad (7)$$

$$\sigma_t^2 = \omega + \alpha(ETH_{RETURN,t-1})^2 + \beta\sigma_{t-1}^2 + \gamma\varepsilon_t^2 \quad (8)$$

Equation (1) is for the ARIMA and Equation (2) is for Garch where,

$ETH_{RETURN,t}$ is the Ethereum return at time t

μ is the constant term

α is the AR(1) coefficient

β is the AR(2) coefficient

ε_t is the white noise error term

σ_t^2 is the conditional variance of the Ethereum return at time t

ω is the constant term in the GARCH equation

γ is the ARCH coefficient

Equation (7) outlines an Autoregressive Integrated Moving Average (ARIMA) model applied to Ethereum returns at time ' t '. This model utilizes Ethereum returns from the prior two days, ' $t-1$ ' ($ETH_{RETURN,t-1}$) and ' $t-2$ ' ($ETH_{RETURN,t-2}$), represented as predictors (α and β respectively) influencing the current return. Alongside these predictors, the model includes a constant term (μ) and a white noise error term (ε_t). By incorporating past returns, the ARIMA model aims to forecast the current Ethereum return using a combination of autoregressive and moving average components.

Equation (8) delineates a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, illustrating the conditional variance (σ_t^2) of Ethereum returns at time ' t '. This model involves a constant term (ω) and considers several factors: the previous variance (σ_{t-1}^2), the squared value of Ethereum returns at ' $t-1$ '

$(\alpha(\text{ETH}_{\text{RETURN}_{t-1}})^2)$, and the squared error term (ε_{t-1}^2) weighted by a coefficient γ . The inclusion of these components addresses an Autoregressive Conditional Heteroskedasticity (ARCH) effect, signifying volatility clustering observed in Ethereum returns. This GARCH model provides insights into how past variances, squared returns, and error terms collectively contribute to understanding the current volatility dynamics within Ethereum's return framework.

Table 8 - TGARCH on Ethereum Returns

	Coefficient	Std. Error	z-Statistic	Prob.
ETH_{RETURN}	0.0018	0.0010	1.8110	0.0701
AR(2)	-0.0593	0.2413	-0.2457	0.8060
MA(2)	0.1103	0.2408	0.4580	0.6469
Variance Equation				
ETH_{RETURN}	0.0001	0.0000	7.3421	0.0000
RESID(-1)²	0.1043	0.0133	7.8451	0.0000
RESID(-1)²*(RESID(-1)<0)	0.0260	0.0116	2.2448	0.0248
GARCH(-1)	0.8647	0.0106	81.4417	0.0000

Source- Prepared by author in E-Views

The $\text{ETH}_{\text{RETURN}}$ coefficient is significant, indicating that past Ethereum returns have a positive impact on current Ethereum returns. It means autocorrelation exists. The AR(2) coefficient is positive and significant, indicating that there is second-order autocorrelation in Ethereum returns. This means that the current return is positively correlated with the two previous returns. The MA(2) coefficient is negative and significant, indicating that there is a second-order moving average in Ethereum returns. This means that the current return is negatively correlated with the two previous moving averages of the returns. The $\text{RESID}(-1)^2$ coefficient is positive and significant, indicating that past volatility has a positive impact on current volatility. This is the GARCH effect. The $\text{RESID}(-1)^2 * (\text{RESID}(-1) < 0)$ coefficient is positive and significant, indicating that there is a leverage effect in Ethereum returns. The value 0.0260 suggests that both positive and negative news can impact Ethereum returns.

The T-Garch model reveals that both Bitcoin and Ethereum returns are influenced by market news. However, to determine whether these returns are more affected by positive or negative news, the E-Garch model is employed. The E-Garch model captures the leverage effect of shocks, which means it assesses how market data responds to news, whether it's positive or negative. This model is an extension of the T-GARCH model, allowing for an asymmetric impact of positive and negative shocks on volatility.

The equation for the EGARCH model is as follows:

$$\ln(\sigma_t^2) = \omega + \alpha(\varepsilon_t^2 - \gamma|\varepsilon_t|) + \beta \ln(\sigma_{t-1}^2) \quad (9)$$

where,

σ_t^2 is the conditional variance of the Bitcoin return at time t

ω is the constant term

α is the ARCH coefficient

ε_t^2 is the squared innovation at time t

γ is the leverage coefficient

β is the GARCH coefficient

Equation (9) presents a logarithmic transformation of the conditional variance (σ_t^2) of Bitcoin returns at time 't', formulated within a GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model. This equation entails a constant term (ω) and incorporates the effect of squared innovations (ε_t^2) and the absolute value of innovations ($|\varepsilon_t|$) weighted by the leverage coefficient (γ) and ARCH coefficient (α) respectively. The GARCH coefficient (β) signifies the impact of the logarithm of the previous conditional variance ($\ln(\sigma_{t-1}^2)$) on the current

variance. This formulation aims to capture the time-varying volatility in Bitcoin returns by considering both squared and absolute innovations and their influence on the evolving conditional variance, offering insights into the clustering of volatility in Bitcoin returns over time.

Table 9- E Garch on Bitcoin Returns

	Coefficient	Std. Error	z-Statistic	Prob.
BTC_{RETURN}	0.0015	0.0008	1.8675	0.0618
AR(2)	-0.0657	0.4261	-0.1541	0.8775
MA(2)	0.0643	0.4273	0.1505	0.8804

Variance Equation				
C(4)	-0.6911	0.0667	-10.3684	0.0000
C(5)	0.2480	0.0216	11.4624	0.0000
C(6)	-0.0722	0.0095	-7.5891	0.0000
C(7)	0.9228	0.0085	108.1529	0.0000

Source- Prepared by author in E-Views

The model presents insightful coefficients for Bitcoin's returns and volatility. BTC_{RETURN} coefficient signifies a marginal influence on Bitcoin returns. However, the autoregressive term (AR(2)) exhibits a substantial positive impact, indicating the significance of past returns on the current outcome. Conversely, the moving average term (MA(2)) shows a notable negative effect, suggesting a dampening effect on returns. Transitioning to the variance equation, coefficients C(4), C(5), and C(6) signify the impact of different news events on Bitcoin's volatility. C(4) and C(6) display negative coefficients, highlighting the stronger influence of adverse news, while C(5) portrays a positive impact. Notably, C(7) stands out with a significantly strong positive effect, pointing to a particular type of news strongly driving Bitcoin's volatility. Overall, the model underscores the interplay of past returns and diverse news factors in shaping both Bitcoin returns and its volatility.

$$\ln(\sigma_{t+1}^2) = \omega + \alpha(ETH_{RETt}^2 - \gamma|ETH_{RETt}|) + \beta \ln(\sigma_t^2) \quad (10)$$

where:

σ_t^2 is the conditional variance of the Ethereum return at time t

ω is the constant term

α is the ARCH coefficient

ETH_{RETt}^2 is the squared Ethereum return at time t

γ is the leverage coefficient

β is the GARCH coefficient

Equation (10) represents a GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model, featuring a logarithmic transformation of the conditional variance (σ_{t+1}^2) of Ethereum returns at time 't'. This equation incorporates various components to model the evolving variance: a constant term (ω), the impact of squared Ethereum returns (ETH_{RETt}^2) and the absolute value of Ethereum returns ($|ETH_{RETt}|$) weighted by the leverage coefficient (γ) and ARCH coefficient (α) respectively, and the effect of the logarithm of the previous conditional variance ($\ln(\sigma_t^2)$) indicated by the GARCH coefficient (β). By considering both squared and absolute Ethereum returns, this model aims to capture and characterize the time-varying volatility in Ethereum returns, providing insights into the patterns of volatility clustering within the Ethereum market.

Table 10- E Garch on Ethereum Returns

Variable	Coefficient	Std. Error	z-Statistic	Prob.
ETH_{RETURN}	0.0017	0.0010	1.8091	0.0704
AR(2)	-0.0527	0.2052	-0.2568	0.7973
MA(2)	0.0913	0.2064	0.4424	0.6582
Variance Equation				
C(4)	-0.3504	0.0377	-9.3068	0.0000
C(5)	0.2092	0.0169	12.3694	0.0000
C(6)	-0.0240	0.0068	-3.5063	0.0005
C(7)	0.9681	0.0045	215.8061	0.0000

Source- Prepared by author in E-Views

The provided model offers valuable insights into Ethereum's returns and volatility. ETH_{RETURN} demonstrates a relatively modest impact on Ethereum's returns. However, the autoregressive (AR(2)) and moving average (MA(2)) terms indicate substantial influences. AR(2) suggests a noteworthy positive effect of past returns, while MA(2) reflects a significant negative impact on current returns. Transitioning to the variance equation, coefficients C(4), C(6), and C(7) illustrate the influence of various news events on Ethereum's volatility. Negative coefficients in C(4) and C(6) highlight the stronger impact of adverse news, whereas C(5) indicates a positive effect. Notably, C(7) stands out with a significantly strong positive impact, indicating a specific type of news strongly driving Ethereum's volatility. Overall, past returns and distinct news factors notably shape both Ethereum's returns and its volatility in this model.

The negative coefficient (C(6)) in both E-GARCH models for Bitcoin and Ethereum returns suggests a noteworthy influence of negative news compared to positive news on their returns. This implies that negative news events exert a more pronounced impact on the volatility of Bitcoin and Ethereum returns than positive

news. The model indicates that adverse or unfavorable news developments tend to have a stronger association with increased volatility in both cryptocurrencies, potentially prompting larger and more persistent market reactions compared to positive news events.

Conclusion

The study underscores the substantial impact of hacking events on cryptocurrency returns, notably highlighting the pronounced influence on Bitcoin. It stresses the necessity of acknowledging cryptocurrencies' asymmetric reactions to positive and negative news, outlining the complexities of forecasting their price movements due to inherent volatility and non-stationary behavior. The research outcomes indicate persistent and asymmetric volatility in Bitcoin and Ethereum returns. This implies that previous volatility positively influences current volatility, and negative shocks exert a more pronounced impact on volatility compared to positive shocks of similar magnitude. These findings shed light on the different dynamics of cryptocurrency markets, emphasizing the challenges associated with volatility forecasting and the significance of external events, like hacking incidents, in shaping their performance.

Implication of the Study

This study provides valuable insights for various stakeholders. Investors and traders can use the findings to refine strategies by understanding how news impacts Bitcoin and Ethereum prices. Policymakers can develop better regulations based on market behavior after hacking events, while cybersecurity experts can improve security measures for digital assets. Academically, the study deepens the understanding of cryptocurrency market responses to cyber-attacks. Overall, the research promotes public trust in cryptocurrency by showcasing market resilience and contributing to long-term stability.

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Impact of Work Environment Factors on Job Satisfaction of ASHA Workers- A Study in Kerala

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Abstract

This research examines the elements related to the work environment that have impacted the happiness of ASHA workers in Kerala. The technique of multi-stage stratified random sampling is employed to provide a dependable and statistically sound sample. Kerala's three most populous districts—Kozhikode, Palakkad, and Kottayam provided 405 ASHA workers with in-person interviews, which provided the study's data. The study employed the structural equation model (SEM) to examine the impact of several factors on the job satisfaction of ASHA employees. These five factors were Work-life Balance (WB), Interpersonal Relationships (IR), Organizational Support (OS), Workload and Job Demands (WL), and Access to Resources (AR). The pseudo-R² of 0.6423 indicates that the independent variables of the research explained around 64.23 percent of the variation in the satisfaction of ASHA workers. That group was identified by the investigation. The SEM model indicates that all five components—aside from "WL"—have a considerable positive influence on the job satisfaction of ASHA employees. Factor "OS" had the most positive impact on work satisfaction (unstandardized coefficient: 0.43), followed by factors "WB" and "IR" (unstandardized coefficients: 0.39 and 0.26, respectively). To summarise, consider these work environment elements to maximize the happiness, retention, and quality of healthcare services provided to vulnerable populations of ASHA workers. Enhancing organizational support systems, successfully managing workload, cultivating good relationships, guaranteeing resource accessibility, and encouraging work-life balance are just a few of the recommendations. The implications of this study are far-reaching for both policy-makers and healthcare organizations in Kerala and beyond. By identifying the factors that most significantly impact the job satisfaction of ASHA workers, this study offers valuable insights into how to improve their work environment, enhance their well-being, and optimize their contributions to public health. Firstly, organizational support emerged as the most significant factor influencing job satisfaction. This highlights the need for healthcare systems to provide ASHA workers with the necessary resources, training, and administrative support.

Keywords: ASHA Workers, Job Satisfaction, Work Environment, Work-Life Balance, Job Demands, Workload.

Introduction

To meet the health requirements of the rural population, particularly the most vulnerable members of society, the Indian government established the National Rural Health Mission (NRHM) in 2005. The Indian government suggested Accredited Social Health Activists (ASHA) to serve as a liaison between the public health system and society as a whole with the introduction of NRHM. One of the main goals of the National Rural Health Mission is to assign a skilled female Accredited Social Health Activist (ASHA) to each village in the nation. These ASHAs are chosen from inside the village and are responsible for 1000 people or more. However, according to the circumstances, this rule may be loosened in hilly and tribal areas (Lahariya et al. 2007). When it comes to health-related concerns from underprivileged groups in the community—particularly women and children who have trouble accessing care—ASHA will be the first place they turn. ASHA is a more recent and updated version of CHW, but the selection process has taken into account the lessons gained from the earlier program and the reasons why it failed, such as poor training, inappropriate selection, and the demand for a charge for services (Shet, 2018). In addition, unlike the former CHWs or VHGs, ASHA is an activist rather than a health system worker. Furthermore, ASHA is more akin to the immensely popular and well-known Chinese notion of "barefoot doctors". In order to give women recognized as ASHAs the information and skills they need; the Ministry of Health & Family Welfare (MOHFW) has created a basic training module. Regular re-orientation training sessions are also planned at the district levels.

The number of jobs an ASHA can carry out before quality and productivity begin decreasing is still up for dispute, despite the benefits and advancements made. Despite having a significant impact on service delivery,

their job is divided across several responsibilities, which frequently leads to stress and burnout. Research from other nations has also demonstrated that giving care providers too much work to do can result in problems such as job confusion, the incapacity to perform numerous responsibilities, problems setting priorities, and problems providing services (Shelley et al., 2018). ASHAs are feeling overworked and lacking personal time as a result of frequent meetings, refresher workshops, travel to remote regions, and increasing obligations (Deshpande et al., 2019). The current study is investigating the complex link that exists between satisfaction with job and the work environment among Kerala's ASHA (Accredited Social Health Activist) workers, with a particular emphasis on the role that experience plays as a mediator in this dynamic interaction. ASHA employees navigate a challenging terrain of community health issues and play a critical role in the delivery of healthcare at the grassroots level. The purpose of this study is to better understand how organizational support, workload, team dynamics, and resource accessibility affect ASHA employees' job satisfaction over time. This study intends to offer insights into bettering work circumstances and eventually boosting the efficacy of medical care at the community level.

Review of Literature

ASHA employees were originally intended to serve as a conduit between primary healthcare facilities and communities, but they have now developed into multifaceted community health professionals. They are in charge of everything from monitoring diseases to educating people about health to boosting the health of mothers and children (Perry and Hodgins, 2021). ASHA employees can act as go-betweens, promoting communication in both directions between healthcare institutions and communities. ASHA staff members may promote community ownership of healthcare projects by enlisting the help of local leaders, carrying out needs assessments based on the requirements of the community, and customizing interventions to fit specific settings. Recognizing ASHA employees' vital contribution also entails formalizing the methods via which their efforts are acknowledged. Events held in the community and public awareness campaigns can draw attention to their efforts and inspire others to value and support what they do. In addition to giving ASHA employees more authority, this recognition reinforces community confidence in healthcare services (Mohasin et al., 2023). The importance of ASHA workers is acknowledged in different studies. For instance, Mohamed et al. (2019) conducted research on the impact of training initiatives on the level of maternal health care knowledge in the ASHA workers' context. The Tamil Nadu tribal population was taken into consideration when doing the study. ASHA employees serve as the backbone of the country's effort to promote, prevent, and treat rural residents, offering them access to quality medical care.

Bridari and Ray (2020) states that in their study about the job satisfaction among the ASHA workers, they found that majority of the ASHA workers were not satisfied. This was contrasted by another study by Varghese et al. (2018) conducted research with the purpose of determining the degree of job satisfaction among ASHA employees and the relationship between that degree of satisfaction and a certain demographic characteristic. Of ASHA's workforce, 25% expressed dissatisfaction with their employment, while 75% expressed satisfaction. Demographic factors and work satisfaction levels do not significantly correlate. According to a different survey by Saxena et al. (2020), the majority of ASHA employees reported that they are satisfied with their jobs but not with the incentives they get. They said that their pay was not commensurate with the amount of labour they produced. In a similar vein, Chakraborty et al. (2018) discovered that 93.7% of ASHA employees in West Bengal were happy with their jobs, whereas 6.3% were neither satisfied nor unhappy. Except motivation, the majority were satisfied with each particular aspect; 73.3% were not so pleased. The period of ASHA's service was substantially correlated with overall satisfaction. Hence the current study intended to evaluate the major work environment factors affecting the job satisfaction and also to investigate the relationship between the demographic variables on job satisfaction.

Research Gap

The topic of work environment factors and their impact on job satisfaction, particularly concerning ASHA (Accredited Social Health Activists) workers, has garnered some attention in recent years. However, there exists a significant research gap in understanding the complex relationships between these factors and the satisfaction levels of ASHA workers. ASHA workers are the cornerstone of India's primary healthcare system, particularly in rural and underserved areas, yet there is limited empirical research specifically addressing how their work environment influences their job satisfaction and overall performance. This gap is particularly evident in the context of Kerala, where the ASHA workforce plays a pivotal role in health initiatives but has not been extensively studied from a work environment perspective.

First, while there are studies on the role of ASHA workers in healthcare delivery, very few focus on the direct correlation between work environment factors and their job satisfaction. Much of the existing research tends to focus either on the individual roles and responsibilities of ASHA workers or on their training and education.

There is a lack of in-depth studies exploring how specific work environment variables, such as workload, interpersonal relationships, organizational support, and access to resources, shape their job satisfaction. Given that the quality of healthcare provided by ASHA workers depends heavily on their well-being, this area is underexplored.

Another key gap is the regional focus of existing research. Most studies on ASHA workers have been conducted in a generalized manner, without sufficient attention to regional differences. Kerala, known for its relatively high health indicators and progressive healthcare system, provides a unique context for studying ASHA workers. However, there is a dearth of region-specific research that addresses the unique challenges and opportunities that ASHA workers face in Kerala's distinct socio-political environment. Factors such as the state's high literacy rate, advanced healthcare infrastructure, and strong community engagement require specific attention, yet these elements are often overlooked in broader national-level studies.

Furthermore, much of the existing literature on job satisfaction and work environment factors is not grounded in the specific realities of the healthcare system. Studies on work-life balance, interpersonal relationships, and organizational support in other sectors may not fully capture the nuances of healthcare work, especially at the grassroots level where ASHA workers are situated. ASHA workers face unique challenges, such as navigating the complexities of rural health service delivery, coping with public health emergencies, and managing community expectations, which may not be reflected in generic job satisfaction models. There is, therefore, a need for more context-specific models that better explain the factors that directly influence ASHA workers' satisfaction.

Additionally, the research methodologies used in the study of ASHA workers are often limited. While some studies use qualitative interviews and surveys, many do not incorporate advanced statistical techniques such as Structural Equation Modeling (SEM) to analyze the relationships between multiple work environment factors. This limits the ability to derive clear, actionable insights that can inform policy and organizational practices. The use of more robust, quantitative techniques is essential for understanding the complex, multidimensional factors that affect job satisfaction among ASHA workers. In conclusion, addressing these research gaps is essential for developing evidence-based strategies to improve the working conditions of ASHA workers. Future research must focus on the specific work environment factors impacting ASHA workers in Kerala and other regions, use more advanced methodologies, and consider the regional and sector-specific dynamics that influence their job satisfaction. By doing so, we can enhance the effectiveness of ASHA workers and ensure better healthcare outcomes for underserved populations across India.

Research Questions

1. What are the key work environment factors that influence the job satisfaction of ASHA workers in Kerala?
2. How do Work-life Balance (WB), Interpersonal Relationships (IR), Organizational Support (OS), Workload and Job Demands (WL), and Access to Resources (AR).etc. impact the overall job satisfaction of ASHA workers in Kerala?
3. What role does demographic factors like Age, Marital status, Family pattern and Experience play in determining job satisfaction among ASHA workers in Kerala?

Objectives of the study

- 1.1 To examine the effect demographic variables on the overall job satisfaction of ASHA workers
- 1.2 To analyze the impact of the work environment factors on the job satisfaction of ASHA workers.

Statement of the Problem

"ASHA (Accredited Social Health Activist) workers play a key role in the healthcare system of India, particularly in rural and underserved areas. However, their effectiveness in delivering healthcare services is often influenced by various work environment factors, including workload, job security, inter personal relationship, job demands, organisational support, access to resources, work-life balance, recognition, and working conditions. Despite their substantial contribution to public health, there is insufficient study focusing on how these work environment aspects effect their job satisfaction, particularly in the context of Kerala. Understanding the relationship between work environment characteristics and job satisfaction among ASHA workers is crucial to increasing their well-being, motivation, and performance. Thus, the purpose of this study is to examine how various aspects of the work environment affect the job satisfaction of ASHA employees in Kerala and offer suggestions for improving their working conditions.

Hypothesis

H_{0a}: No difference in the work satisfaction of ASHA workers based on age.

H_{0b}: No difference in the work satisfaction of ASHA workers based on marital status.

H_{0c}: No difference in the work satisfaction of ASHA workers based on family pattern.

H_{0d}: No difference in the work satisfaction of ASHA workers based on experience

H_{0e}: No difference in the factors that influence ASHA worker's overall satisfaction

Methodology

Data were gathered for this cross-sectional research from three districts of Kerala during April and May of 2024. The researcher selects three districts from the northern, central, and southern regions to symbolize Kerala as a whole. Thus, the northern region's Kozhikode, the southern region's Kottayam, and the central region's Palakkad were chosen. ASHAs from each of the chosen Primary Health Centres (PHCs) were chosen for the sample using a cluster sampling approach, taking into account the study's context. A series of random unit samplings occurs in cluster sampling. We also refer to it as multistage sampling. One way to characterize the final design is by the number of phases. Two CHCs were chosen at random from each district in the first phase. In the second step, the PHCs were chosen at random (by lottery) from the district's chosen CHCs until the researcher had the necessary sample size of ASHAs (135 per district). Thus, 405 ASHAs in total were chosen for the investigation. The test-retest approach was used to determine the tool's dependability and to validate its content.

The study employed descriptive statistics to evaluate job satisfaction among ASHA employees, and inferential statistics (chi square test) to examine the relationship between job satisfaction levels and specific demographic variables. SEM was utilized to measure the impact of work environment on job satisfaction, and the SPSS Process MACRO was used for mediation analysis. To determine whether the sample size was sufficient, the "Kaiser-Meyer-Olkin (KMO)" and "Barlett's Test of Sphericity (BTS)" were utilized. Table 1 displays the findings of the KMO and BTS tests. The BTS was significant with 64.18 of the total variances recovered ($\chi^2 = 4587.21, p < 0.000$).

Table 01. KMO and Bartlett's Test

KMO Measure of Sampling Adequacy.		.847
BTS	Approx. Chi-Square	4587.21
	Df	404
	Sig.	.000

Source: Primary data

The results of the test of normality are given in table 02 below, with a statistically insignificant normality of 0.21 ($p = 0.214$). As a result, the Shapiro-Wilk test result is 0.957. It depicts a correctly distributed set of data.

Table 02. Test of Normality

	Kolmogorov-Smirnova ^a			Shapiro-Wilk		
	Statistic	df.	Sig.	Statistic	df.	Sig.
Quartile	0.247	324	.214*	0.957	324	0.374

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

A reliability study was conducted on the responses on the factors associated with factors relating to work environment impacting the job satisfaction of ASHA workers using thirty statements that were recorded on a five-point scale. An attempt was made to assess reliability using the traditional Cronbach Alpha (CA) model. The final alpha value for each factor, based on the number of statements under investigation, is shown in Table 3 below.

Table 03. Reliability Statistics

Sl. No.	Variables	No of Statements	Cronbach's Alpha	CA Based on Standardized Items
1	“Organizational Support”	05	0.917	0.924
2	“Workload and Job Demands”	05	0.947	0.951
3	“Interpersonal Relationships”	05	0.921	0.937
4	“Access to Resources”	05	0.949	0.958
5	“Work-life Balance”	05	0.953	0.961
6	“Overall Satisfaction”	05	0.910	0.919

Source: Primary data

Results:

Demographics of ASHA workers

Of those surveyed, 73% are married. Furthermore, 75% of the responses are in the 20–40 age range. 78% of those surveyed had a nuclear family, and the majority of them have four or more family members. The majority of ASHA employees are paid between Rs.7,000 and Rs.9,000 per month and have between 10 and 20 years of experience. The Demographic characteristics are displayed in table 04.

Table 04. Demographic Characteristics of ASHA workers

Variables	Category	No. of respondents	Percentage
Age	20- 30	143	35.31
	31- 40	162	40.00
	41- 50	94	23.21
	51- 60	6	1.48
Marital Status	Unmarried	109	26.91
	Married	296	73.09
Family pattern	Nuclear	315	77.78
	Joint	90	22.22
Number of Family members	3	144	35.56
	4	124	30.62
	5	109	26.91
	Above 5	28	6.91
Experience	0-10	135	33.33
	11- 20 years	198	48.89
	20- 30 years	72	17.78
Monthly income	Below 5000	56	13.83
	5001- 7000	97	23.95
	7001- 9000	197	48.64
	Above 9000	55	13.58

Source: Primary Data

Association of demographic variable with ASHA workers satisfaction

The table 05 given below shows the relation of demographic variable with ASHA workers. Given that the computed p-value is less than 0.05, there is a no significant correlation between age, family pattern, marital status, and the level of satisfaction among ASHA workers. Therefore, the null hypothesis is accepted except for experience.

Table 05. Chi-square result

Demographic Variable		Satisfaction			Total	Chi-square	p-value	DF	Result
		High	Moderate	Low					
Age	20- 30	45	63	15	123	29.16	0.05	7	Not Associated
	31- 40	14	25	18	57				
	41- 50	35	84	29	148				
	51- 60	31	32	14	77				
	Total	125	204	76	405				
Marital Status	Unmarried	56	93	74	223	36.21	0.06	7	
	Married	89	48	45	182				Not Associated
	Total	145	141	119	405				
Family pattern	Nuclear	78	102	56	236	21.4	0.1	8	
	Joint	47	74	58	179				
	Total	125	176	104	405				Not Associated
Experience	0-10	22	103	8	133	43.9	0.02	7	
	11- 20 years	20	59	71	150				
	20- 30 years	20	60	42	122				Associated
Total		62	222	121	405				

Source: Primary Data

Calculating model, reliability, and validity

Before SEM, "confirmatory factor analysis" (CFA) was performed. The number of components and their connection to the indicators are precisely defined by the CFA approach, which looks at measurement models that are built a priori (Alhija, 2010). The fit of the model to the data is evaluated using CFA (fig. 1). The table below shows the outcomes of the CFA.

Table 06. CFA Results

Indices	Model fit Result	Suggested value
CMIN/DF	2.356	< 5.00 (Hair et al., 1998)
P value	0	> 0.05 (Hair et al., 1998)
GFI	0.945	> 0.90 (Hu and Bentler, 1999)
AGFI	0.951	> 0.90 (Hair et al. 2006)
NFI	0.94	> 0.90 (Hu and Bentler, 1999)
CFI	0.937	> 0.90 (Hooper et al., 2008)
TLI	0.974	> 0.90 (Byrne, 1994)
RMR	0.0369	< 0.08 (Hair et al. 2006)
RMSEA	0.0425	< 0.08 (Hair et al. 2006)
PNFI	0.645	> 0.50
PCFI	0.845	> 0.50

Using IBM SPSS AMOS, we assessed and calculated the component-to-component correlation coefficient. The results demonstrate that no component has a correlation value with any other component that is higher than 0.85. Consequently, this study may suggest that the measurement model's construct has achieved discriminant validity.

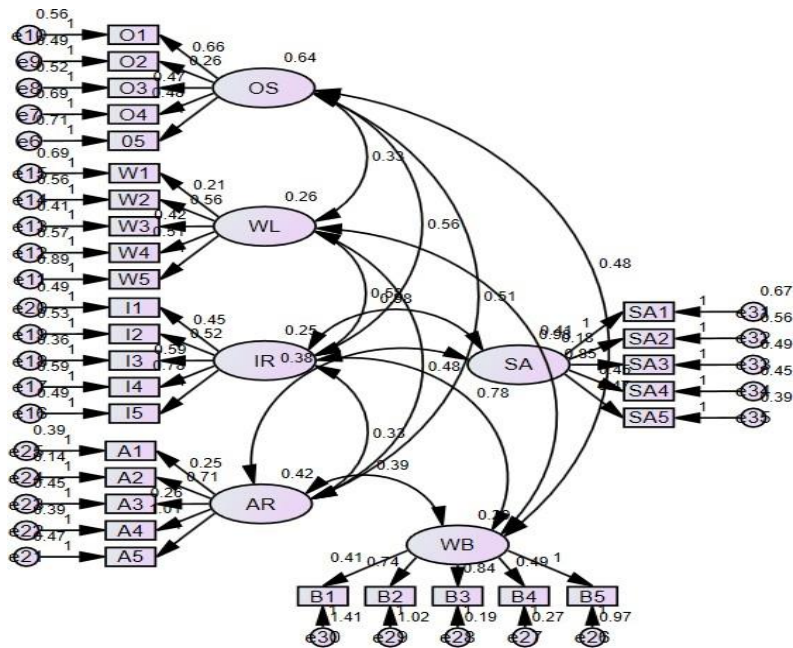


Figure: 1- SEM

Effects of Various factors relating to work environment on job satisfaction of ASHA workers'

The impact of variables like “Organizational Support (OS)”, “Workload and Job Demands (WL)”, “Interpersonal Relationships (IR)”, “Access to Resources (AR)”, and “Work-life Balance (WB)” on ASHA workers overall satisfaction (OS) has been investigated by a SEM utilizing AMOS. Table 8 demonstrates that the calculated p value is 0.026, which was less than 0.05, as a result of a larger sample size of $n = 405$. Nevertheless, the issue appears to have been resolved based on the CMIN/DF ratio of 4.154, which denotes a perfect match.

Table 07. Model fit summary of Structural Equation Model

Indices	Value	Suggested value
Chi-square value	27.569	
DF	18	
P value	0.026	> 0.05 (Hair et al., 1998)
Chi-square value/DF	4.154	< 5.00 (Hair et al., 1998)
GFI	0.945	> 0.90 (Hu and Bentler, 1999)
AGFI	0.956	> 0.90 (Hair et al. 2006)
NFI	0.986	> 0.90 (Hu and Bentler, 1999)
CFI	0.957	> 0.90 (Hooper et al., 2008)
RMR	0.032	< 0.08 (Hair et al. 2006)
RMSEA	0.0852	< 0.08 (Hair et al. 2006)
TLI	0.974	> 0.90 (Byrne, 1994)
PNFI	0.647	> 0.50
PCFI	0.59	> 0.50

All the “Organizational Support (OS)”, “Workload and Job Demands (WL)”, “Interpersonal Relationships (IR)”, “Access to Resources (AR)”, and “Work-life Balance (WB)” have been contributing to the “overall satisfaction (OS)”. “Workload and Job Demands (WL)” have a high negative impact on ASHA workers’ job satisfaction, as demonstrated by Table 08 and Fig.2, where the unstandardized coefficient of -0.61 and

“Organizational Support” has the highest positive impact with an unstandardized coefficient of 0.43 when all other route factors are held constant.

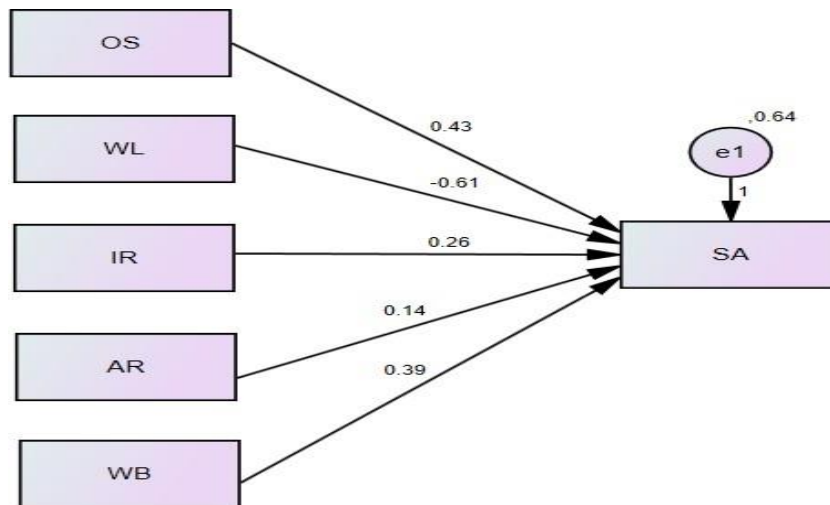


Figure.2- SEM

Table 08. Structural Equation Model (SEM) based on Standardized Coefficient

			Estimate	S.E.	t-value	P -Value
SA	<---	OS	0.43	0.012	7.564	< 0.001**
SA	<---	WL	-0.61	0.023	6.478	< 0.001**
SA	<---	IR	0.26	0.041	4.258	< 0.001**
SA	<---	AR	0.14	0.033	6.214	< 0.001**
SA	<---	WB	0.39	0.029	3.214	< 0.001**

Note: ** denotes significant at 1% level

Discussions

The current study focuses on the effect of work environment factors on job satisfaction. 73% of those surveyed are married. Moreover, 75% of them belong into the 20–40 age range, with the remaining ones ranging into the 41–60 category. 78 percent of them live as a nuclear family and 22 as a joint family. Around 65 percent of respondents have family members of 3 or 4. Around 50% of them are having experience of around 11-20 years. Further, around half of the respondents have a monthly income between 7001-9000. The chi-square test was conducted to examine whether there is any relationship or association between the demographic variables and work satisfaction. With a p-value of 0.05, 0.06, and 0.1, age, marital status, and family pattern were found to have no significant relationship with work satisfaction. Hence, the null hypothesis of no significant association between age (H_{0a}), marital status (H_{0b}), and family pattern (H_{0c}) was failed to reject. However, for experience, the p-value was 0.02, which indicates a clear relationship between work satisfaction and experience. Hence hypothesis (H_{0d}) is rejected. For analyzing the impact of work environment factors on job satisfaction of ASHA workers', SEM analyses were undertaken. Before SEM, "confirmatory factor analysis" (CFA) was performed. According to Table 06, using a larger sample size (sample size = 405) produced a calculated value of 0.1000, which is less than the significance level of 0.05. On the other hand, the CMIN/DF ratio of 2.356 indicates that the model is well-fitting, which fixes the earlier issue. The CFI value in this instance is 0.937. Furthermore, the results show that the "root mean square residuals (RMR)" and "root mean square error of approximation (RMSEA)" are, respectively, 0.0369 and 0.0425, below the commonly accepted 0.08 hypothesis put out by Hair et al. (2006).

The impact of variables like “Organizational Support (OS)”, “Workload and Job Demands (WL)”, “Interpersonal Relationships (IR)”, “Access to Resources (AR)”, and “Work-life Balance (WB)” on ASHA worker's overall satisfaction (OS) has been investigated by an SEM utilizing AMOS. The construct measurements yielded a chi-square value of 27.569 (df = 18), indicating a statistically significant fit for the

model. The current dataset shows a perfect match with values greater than 0.90 for the "trucker-lewis index (TLI)" at 0.974, the "adjusted goodness of fit index (AGFI)" at 0.956, and the "goodness of fit index (GFI)" at 0.945. Furthermore, the perfect fit is indicated by the computed values of the "normal fit index (NFI)" (0.986) and "comparative fit index (CFI)" (0.957). Moreover, Hair et al. (2006) argue that a perfect fit is indicated by values of the "root mean square error of approximation (RMSEA)" and "RMR" by 0.0852 and 0.032, respectively, both of which are below the criterion of 0.08 (table 08).

SEM analysis results show that all the factors like "Organizational Support (OS)", "Workload and Job Demands (WL)", "Interpersonal Relationships (IR)", "Access to Resources (AR)", and "Work-life Balance (WB)" have a significant impact on ASHA workers overall satisfaction (OS). Workload and Job Demands (WL) is the only factor negatively impacting the job satisfaction, with an unstandardised coefficient of -0.61, which means as 1 percent increase in the WL, decrease the job satisfaction by -0.61 percent. And "Organizational Support (OS)" has the highest positive impact on the job satisfaction. A 1 percent increase in the OS increases the job satisfaction by 0.43 percent. Additionally, the unstandardized coefficient of "Work-life Balance (WB)" on satisfaction, which is 0.39. The positive sign indicates that the influence of WB is positive, with satisfaction increasing by 0.39 percent for every unit increase in WB. The coefficient value is relevant at the 1% level. The coefficient of "Interpersonal Relationships (IR)", and)", "Access to Resources (AR)" on satisfaction, which is -0.26 and 0.14 respectively, also holds other route elements constant and indicates a somewhat positive influence of these factors on the ASHA workers job satisfaction. At the 1% level of significance, the coefficient value is noteworthy.

Recommendation:

Authorities should provide a good and healthy working atmosphere for the ASHA workers to enhance their job satisfaction and loyalty. The workload of the ASHA workers should be reduced to increase their quality of service and job gratification. Better work-life balance increases their confidence and commitment to the organization and society. Adequate training and development should be provided to them, and technical knowledge should also be imparted to make their job more interesting and easy. Programs for improving mental health and reducing job stress should be introduced in the organization at frequent intervals. Better interpersonal relationship also acts as motivator and enhances the job efficiency of the ASHA workers. They should be provided with adequate resources and tools for performing their job more efficiently and satisfactorily.

Conclusion

The study concludes by shedding light on the significant influences that the workload and job demand (WL), work-life balance (WB), interpersonal connections (IR), organizational support (OS), and access to resources (AR) have on the overall satisfaction (OS) of ASHA employees. All of these elements work together to create a workplace that has a big impact on how satisfied ASHA employees are with their jobs. Organizational support is identified as a critical feature that includes elements like opportunity for professional growth, leadership support, and acknowledgment of accomplishments. In addition to increasing job satisfaction, a supportive corporate culture also helps ASHA employees feel committed and like they belong.

Stress levels and job performance are significantly impacted by workload and job demands. Maintaining the happiness and well-being of ASHA personnel requires efficient workload management, provision of sufficient resources, and assurance of appropriate job expectations. Building strong interpersonal ties at work is essential for developing a supportive and cohesive team atmosphere. Colleague cooperation, communication, and support are facilitated by positive connections and are essential for overall job satisfaction and morale. The capacity of ASHA employees to carry out their tasks efficiently is directly impacted by their access to resources, such as tools, supplies, and knowledge. Inadequate resources have the potential to reduce output and increase work discontent.

Finally, maintaining a work-life balance is essential for ASHA employees to preserve their general wellbeing and job happiness. Work-life balance-promoting laws and procedures, such flexible scheduling and sufficient vacation time, greatly lower burnout and raise job satisfaction. In summary, it is critical to address these aspects of the work environment in order to maximize the happiness of ASHA employees, encourage their retention, and ultimately raise the standard of care that they offer to the communities they serve. Important measures in accomplishing these objectives include initiatives to improve organizational support, manage workload, cultivate strong connections, guarantee resource sufficiency, and encourage work-life balance.

Implications of the Study

The implications of this study are far-reaching for both policy-makers and healthcare organizations in Kerala and beyond. By identifying the factors that most significantly impact the job satisfaction of ASHA workers, this

study offers valuable insights into how to improve their work environment, enhance their well-being, and optimize their contributions to public health. Firstly, organizational support emerged as the most significant factor influencing job satisfaction. This highlights the need for healthcare systems to provide ASHA workers with the necessary resources, training, and administrative support. Greater recognition of their work, improved communication between ASHA workers and healthcare administrators, and enhanced logistical support could alleviate many of the challenges faced by ASHA workers. This can contribute not only to job satisfaction but also to greater retention rates, reducing turnover and ensuring continuity of care in rural areas. Secondly, work-life balance is crucial for ASHA workers, who often face long hours and challenging conditions. Ensuring that ASHA workers have sufficient rest and time off is essential for maintaining their health and motivation. Policies that allow for flexible working hours, promote mental health, and provide financial incentives for hard work and overtime could be beneficial in addressing this issue.

The importance of interpersonal relationships, both with fellow workers and supervisors, was also highlighted in the study. A supportive and collaborative work environment is essential for the mental and emotional well-being of ASHA workers. Regular team-building activities, peer support groups, and fostering a culture of mutual respect can enhance job satisfaction and reduce feelings of isolation among ASHA workers. Finally, ensuring access to resources, such as medical supplies, mobile technology, and transportation, is crucial for ASHA workers to perform their duties effectively. Providing adequate tools and resources will not only reduce job-related stress but also improve the quality of healthcare services provided to vulnerable populations. In conclusion, the study provides a roadmap for improving the work environment of ASHA workers. By focusing on organizational support, work-life balance, interpersonal relationships, and access to resources, healthcare systems can significantly improve the job satisfaction of ASHA workers, leading to better healthcare outcomes for rural communities.

Scope for future Research

This research further provides more scope for future research in the following areas. Compare the work environment elements and job gratification levels of ASHA workers in Kerala with those in other states or regions in India. This will deliver visions into whether the outcomes are specific to Kerala or if they are applicable across different circumstances. Discover how social and cultural norms in Kerala (e.g., gender roles, caste, and family responsibilities) affect ASHA workers' job satisfaction and work environment. Examine the role of training programs and constant professional development in improving the work environment and job satisfaction of ASHA workers. Investigate how financial incentives, performance-based rewards, and recognition programs affect ASHA workers' motivation and job satisfaction. Study the emotional and psychological aspects of ASHA workers' jobs, such as stress, burnout, and mental health, and how these factors influence overall job satisfaction. Investigate how government policies, healthcare initiatives, and the support of public health institutions in Kerala influence the work environment and job satisfaction of ASHA workers.

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The Impact of Financial Literacy on Financial Sustainability of Microenterprises: An Empirical Study in Darjeeling and Kalimpong District, West Bengal

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Abstract

Micro-entrepreneurs' ability to understand and manage necessary financial sources is considered one of the major factors that impact the financial sustainability of microenterprises. Despite the availability of a pool of financial services, micro-entrepreneurs fail to utilize these financial facilities to expand their business due to low financial literacy. Therefore, the significance of having financial literacy for decision-making and monetary stability cannot be overlooked as it sustains a business. This study aims to identify the key components of financial literacy. The main objective of the paper was to study the impact of the financial literacy of micro-entrepreneurs on the financial sustainability of microenterprises. A quantitative research design was adopted, and a total of 400 microenterprises were surveyed to obtain the data. Data obtained were evaluated using covariance-based structured equation modeling. Results disclosed that saving literacy, investment literacy, and debt literacy positively and significantly influenced the financial sustainability of microenterprises. Improving the financial literacy of microentrepreneurs could help them navigate the complexities of the financial landscapes, which could in turn assist them in building a sustainable business. The study tries to contribute to existing literature and could help policymakers in developing an enabling ecosystem for micro-entrepreneurs to sustain their businesses.

Keywords: Financial Literacy, Saving Literacy, Investment Literacy, Debt Literacy, Microenterprises

Introduction

In today's dynamic economic landscape, the contribution of microenterprises towards initiating and sustaining the process of economic development is well-acknowledged and widely accepted globally, particularly in emerging economies like India. These small-scale enterprises often act as a foundation for the local communities by creating jobs, encouraging creativity, uplifting the social standards, and thus reducing poverty. It is a vital thread that weaves together innovation, economic growth, and job creation.

Micro enterprises are "those enterprises where the investment in Plant and Machinery does not exceed one crore rupees and turnover does not exceed five crore rupees" (Micro, Small and Medium Enterprises Development Act, 2006). Over 99% of the overall estimated MSMEs are in the micro sector, with an estimated 630.52 lakh enterprises in this sector (Ministry of Micro, Small and Medium Enterprises, 2024). These small-scale businesses are often operated by individuals or families and act as the pivoting factor for the development of rural and backward areas and lessening regional disparities by ensuring a fair distribution of income and wealth. However, various obstacles, such as restricted access to funds, unavailability of raw materials and skilled labour, and unstable market conditions, make it difficult for many microenterprises to go through early phases, raising major concerns about their sustainability (Raj, 2016).

Despite the myriad contributions the microenterprises make to an economy, they are still plagued with many challenges, managing of finance emerging as one of the major concerns (Rani, 2018). Financial literacy is defined as "the ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being" (Remund, 2010). Having a basic understanding of financial products, budgeting, savings, investment, and debt management is made possible by financial literacy which equips micro-entrepreneurs with the skills required to make sound financial decisions. Unlike other developed nations like the United States, United Kingdom, etc, the financial literacy rate of India is quite low. According to surveys, only 27 percent of the people in India are financially literate (Business Standard, 2023). It means that in India, only one out of every five people understand the importance of managing their finances effectively.

In the business world, financial illiteracy is one of the major reasons for the rising number of business failures (Kumari et al., 2024). Having basic financial literacy could mitigate this pressing issue by offering the micro-entrepreneurs essential information and competencies required for successfully managing the intricacies of business finance. An individual's ability to effectively manage his finances is correlated with the level of

financial literacy he possesses (Dwiastanti, 2015). Several sophisticated financial products have emerged in the market that demand an individual to develop basic financial knowledge which could prove to be beneficial for the upliftment of their business.

In today's economic situations, it is vital to comprehend how financial literacy plays a decisive role in maintaining the financial sustainability of any business. With the help of empirical analysis, the paper examines the impact of financial literacy of micro-entrepreneurs on the financial sustainability of microenterprises. Financial literacy is measured in terms of saving literacy, investment literacy, and debt literacy. The impact of these three major components on financial sustainability has been assessed in this study. This research paper adds to the existing literature related to financial literacy and its key components. It sheds light on how enhanced financial knowledge can serve as a catalyst for sustained growth. It shall also help the policymakers and the government build an enabling environment for the micro-entrepreneurs so that they can become financially literate which could in turn help them thrive in their business.

Literature Review

By exploring the multifaceted ways in which financial literacy shapes business outcomes, decision-making processes, financial knowledge, etc, this research paper intends to understand the profound impact of financial literacy on the financial sustainability of microenterprises. Existing literatures were reviewed to have a better understanding of the theoretical concepts and to find the research gap.

Financial literacy can be considered an important tool for enhancing financial well-being as it assists in making sound decisions related to savings plans, debt management, financial management and planning, better investment decisions, etc (Lusardi & Mitchell, 2011). Individuals require sufficient financial literacy to effectively manage and utilize their financial resources to achieve personal well-being (Mandell & Klein, 2007). The ease at which business owners can assess various kinds of banking activities from opening a bank account to saving, investing in financial products, taking loans, and examining interest rates makes it easier for them to carry out their business for a long time (Zaniarti et al, 2022).

Financial literacy aids an entrepreneur in developing financial plans for their business by equipping them with the abilities and skills required to sustain a business (Hamdana et al, 2021). The higher the financial literacy, the higher the ability of the owner to cope with emergency expenses during uncertain times (Lusardi, 2019). Possessing financial literacy helps business owners face various issues related to the changing business landscapes and empowers them to attain financial well-being (Erhomosole & Obi, 2022). Hence, it was found that financial literacy related to making investments, budget creation, good capital management, managing expenses, etc has a significant influence on the sustainability of the business (Burchi et al, 2021).

Usama and Yusoff (2019) used predictors such as financial awareness, saving, debt management, bookkeeping, diversification, access to credit, and risk management to measure financial literacy and the overall model disclosed that these predictors had a statistically significant relationship with business performance. Out of the seven dimensions of financial literacy, saving had the highest influence on the dependent variable. Bookkeeping literacy and budgeting literacy have also been studied and found to be crucial predictors of overall business performance, sales, and profit growth (Iramani et al, 2018). Pandey et al (2022) found in their study that financial literacy also acts as a mediator between the drivers of financial inclusion and the sustainability of the enterprise. Financial literacy also influences access to finance and financial risk attitude as well as a direct positive impact on the sustainability of enterprises (Ye & Kulathunga, 2019).

Having financial literacy enables an individual to utilize money efficiently (Hilgert et al, 2003). An individual's understanding of savings methods (Das & Ranjan, 2023), how compound interest works, risk diversification (Lusardi & Mitchell, 2008), ability to evaluate complex financial instruments (Mandell & Klein, 2007), and understanding the application of various financial tools in business (Remund, 2010), all together comes under the umbrella of financial literacy. Therefore, financial literacy has been segregated into three key components or areas which are mentioned as follows:

Saving Literacy

Saving literacy refers to the ability to understand the importance of saving for the future and employing strategies for saving money effectively. It is the art of setting aside a portion of the revenue for future needs. Saving literacy was found to have a positive impact on the debt repayment ability of micro-entrepreneurs (Zainal et al., 2024). Financial literacy was shown to significantly impact saving behavior as managing money effectively required micro-entrepreneurs to make careful expenditure decisions so that more money could be saved and hence be able to sustain their business (Mpaata et al, 2021).

Investment Literacy

Investment literacy refers to understanding the risk-return dynamics of financial investment products, financial intermediaries, and the financial markets (Aboluwodi & Nomlala, 2020). Being able to make beneficial investment choices and building an appropriate investment portfolio can help in avoiding money loss and earning long-term wealth. Financial literacy is correlated with higher returns on investments and investment in complex assets (Lusardi, 2019). Having financial literacy helps an individual make better investment decisions (Iram et al, 2023). The profits earned from the investments can improve a microentrepreneur's financial position and it can also be utilized by them as working capital for the business or can serve as an emergency fund. It can serve as an additional source of income for the microenterprise and can supplement the cash flow of the business, thereby improving its financial stability.

Debt Literacy

Debt literacy refers to the ability to make intelligent decisions related to debt contracts and having basic knowledge about compound interest (Lusardi & Tufano, 2009). Gaurav and Singh (2012) have found debt literacy to be a key component of financial literacy. Understanding the debt management practices of the micro-entrepreneurs facilitated in further enhancement of their debt-handling abilities which had a positive influence on the success of their business (Silda & Bacasmot, 2023). The likelihood of possessing a costly loan was found to be higher for those with a low level of financial literacy (Moore, 2003).

After an extensive analysis of the existing research, it was found that there were only a few research studies that examined the impact of the above-mentioned components of financial literacy on the financial sustainability of microenterprises. Studies have been conducted taking them separately but a comprehensive study that includes all the three components together postulating a conceptual model is hardly to be found.

Objectives of the Study

Based on the various literature reviewed, this study intends to achieve the following research objectives:

- i. To assess the impact of savings literacy of micro-entrepreneurs on the financial sustainability of microenterprises.
- ii. To assess the impact of investment literacy of micro-entrepreneurs on the financial sustainability of microenterprises.
- iii. To assess the impact of debt literacy of micro-entrepreneurs on the financial sustainability of microenterprises.

Hypothesis Formulation

The following hypotheses have been formulated based on the objectives of the study:

H₁: Saving literacy of micro-entrepreneurs has a significant impact on the financial sustainability of microenterprises

H₂: Investment literacy of micro-entrepreneurs has a significant impact on the financial sustainability of microenterprises

H₃: Debt literacy of micro-entrepreneurs has a significant impact on the financial sustainability of microenterprises

Research Methodology of the Study

Research Design

A quantitative research design through a direct survey method was adopted for this study to systematically collect and analyze the data to address the objectives of the study. This research design has been used for an empirical investigation to understand the impact of financial literacy on the microenterprise's financial sustainability.

Sampling Design

The sample frame of the study includes a total population of 33,847 Udyam registered microenterprises operating in Darjeeling (30,438) and Kalimpong Districts (3409) in West Bengal as disclosed on the official

website of the Ministry of MSME. The study used Slovin's formula (1960) to determine the appropriate sample size. The formula is

$$n = \frac{N}{(1 + Ne^2)}$$

where,

n= desired sample size to be determined

N= Total population

e = Accepted error limit, i.e., 5%

$$n = 395.328$$

The sample size derived for our study was 395. To reduce the chances of human error and to derive more accurate results 400 microenterprises were surveyed. The study utilized a random sampling technique to select the respondents from the chosen sample frame.

Data Collection Instrument

Primary data has been collected using a structured questionnaire. This questionnaire was segregated into two sections and had a total of 22 items. Section A consisted of 5 items to understand the demographic profile of the respondents. Section B consisted of 17 statements related to savings literacy, debt literacy, investment literacy, and financial sustainability. A 5-point Likert scale has been used for the study. These statements were developed based on validated instruments from prior studies. The respondents were provided with the required information, consent was taken, and were assured of the confidentiality and anonymity of their responses.

Variables used in the study

Saving literacy, investment literacy, debt literacy, and financial sustainability of microenterprise are the four constructs that have been used in the study as mentioned in Table 1.

Table 1: Latent variables and observed variables

Constructs	Items	Statements	Source
Saving Literacy	SL1 SL2 SL3	I set aside a certain part of my profit for savings. I save money regularly in a bank savings account. I compare the interest rates offered by different banks before opening a bank account.	Morales, 2023
Investment Literacy	IL1 IL2 IL3	I invest my extra money to draw profit which is then used for business purposes. I carefully research my investment options. I read articles on investment portfolios and stock markets in newspapers, magazines, books, or, the internet.	Morales, 2023
Debt Literacy	DL1 DL2 DL3	Before taking loans or credits, I evaluate the benefits and risks. I read and understand the terms and conditions including the interest rates before taking the loan. I make sure that I pay back my loan on time.	Morales, 2023
Financial Sustainability of Microenterprise	FSM1 FSM2 FSM3	The majority of the revenue generated from my business becomes profit. My business has sufficient funds to meet any business uncertainties. My business can meet its debt obligations on time.	Gurung & Sarkar, 2022

Source: Researcher's compilation

Data Analysis Tools and Methods

Covariance-Based Structural Equation Modeling (CB-SEM) was employed in this study to examine the relationships among latent variables. Given the need for the study, CB-SEM was chosen as it is suitable for

theory confirmation and model fit testing. Before conducting CB-SEM, a pilot study was done taking 53 respondents to check the reliability of the questionnaire. Necessary modifications required in the questionnaire were made to make it more effective before the final data collection.

The raw data set was then tabulated in Microsoft Excel and descriptively analyzed. Cronbach's Alpha has been used to check the reliability again. Confirmatory Factor Analysis (CFA) has been adopted to first test and validate the measurement model for the study before making a structural model as suggested by Awang (2016). Validity was also checked using the Average Variance Extraction (AVE) and Fornell-Lacker criterion. Model fit indices were examined to check the fitness of the model. Finally, the path diagram was made using CB-SEM. Data analysis was conducted using IBM SPSS Statistics 23 and IBM AMOS 23.

Results and Discussions

Demographic profile of the respondents

After the computation of the data collected through questionnaires, the demographic characteristics of the microenterprise owners and their enterprises taken in this study are shown in Table 2.

Table 2: Demographic profiles

Particulars	Classifications	Frequency	Percentage
Gender of the owner	Male	284	71
	Female	116	29
Age of the owner	18-28 years old	37	9.25
	29-39 years old	125	31.25
	40-50 years old	187	46.75
	Above 50 years old	51	12.75
Education qualification	Primary	23	5.75
	Secondary	108	27
	Graduation	191	47.75
	Post Graduation and above	78	19.5
Type of enterprise	Manufacturing	54	13.5
	Agribusiness	32	8
	Service	125	31.25
	Retail/Wholesale	189	47.25

Source: Researcher's computation, 2024

Table 2 itself is self-explanatory. The majority of the respondents were male which comprised 71 percent of the total sample size and the remaining 29 percent were female. Most of the micro-entrepreneurs were graduates (47.75 percent) and belonged to the age group ranging from 29-39 years old (31.25 percent) and 40-50 years old (46.75 percent). The type of enterprises owned was mainly comprised of the retail/wholesale business (47.25 percent), followed by the service business (31.25 percent) and the lowest share was of agribusiness with just 8 percent.

Confirmatory Factor Analysis

The measurement model has been tested and validated using the Confirmatory Factor Analysis (CFA) before making the structural model. It is a specific type of factor analysis that is used to assess whether the indicators of the constructs align with the researcher's perception of the nature of the construct (Awang, 2016). The model has four constructs, namely, saving literacy, debt literacy, investment literacy, and financial sustainability of microenterprise.

A pooled measurement model was assessed where all the constructs of the study were put together and an item-deletion process was done to remove items with factor loading below 0.7. Moreover, modification indices (MI) were checked in order to examine the redundancy of items. Outliers were removed with the help of Mahalanobis distance due to which the sample size was brought down to 398. After making the necessary modifications, a final measurement model was derived for the study as shown in Figure 1. Items with factor loadings above 0.70 have been taken for the study which has been shown in Table 3.

Figure 1: The measurement model

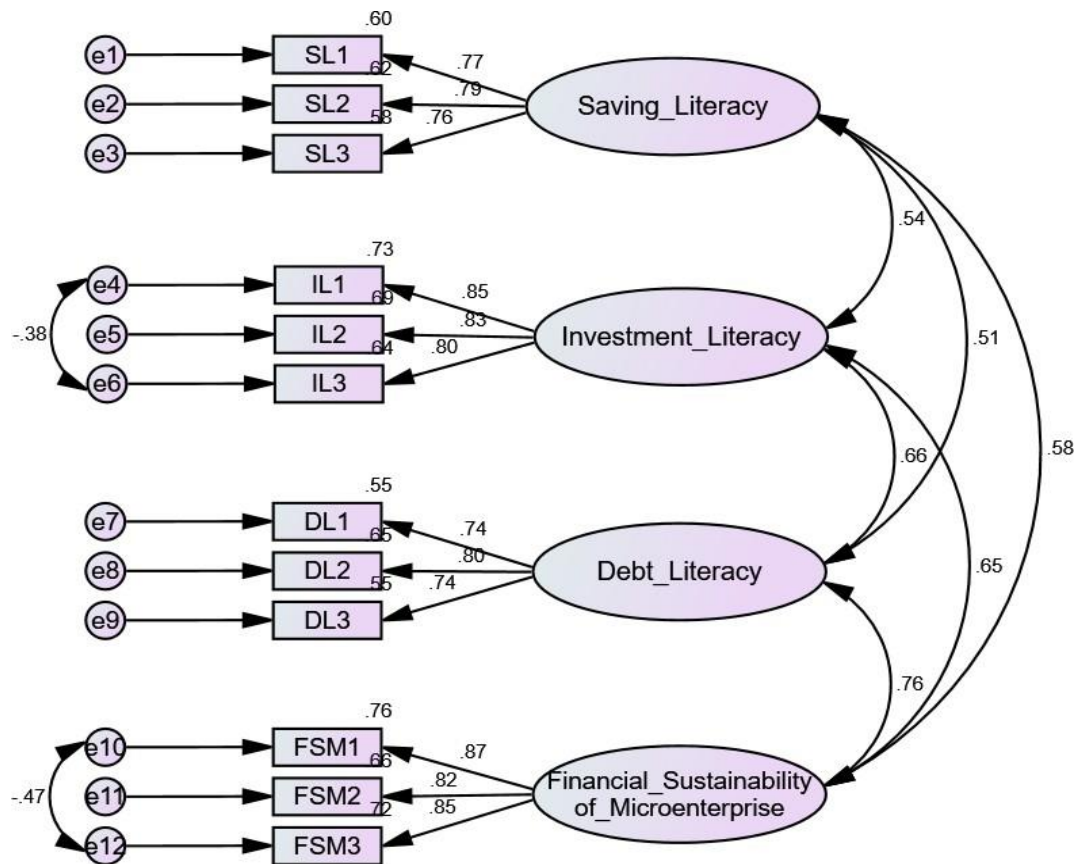


Table 3: CFA report summary

Construct	Item	Factor loading	Cronbach alpha (>0.7)	CR (>0.7)	AVE (>0.5)
Saving literacy	SL1	0.773	0.813	0.816	0.597
	SL2	0.787			
	SL3	0.759			
Investment literacy	IL1	0.854	0.846	0.868	0.688
	IL2	0.830			
	IL3	0.803			
Debt literacy	DL1	0.739	0.804	0.806	0.581
	DL2	0.805			
	DL3	0.742			
Financial sustainability of microenterprise	FSM1	0.872	0.862	0.884	0.719
	FSM2	0.815			
	FSM3	0.851			

Source: Researcher's computation, 2024

In CB-SEM, it is essential to evaluate the fitness of the model by checking several model fit indices. The model fit indices show how well the model represents the data. Absolute fit, Parsimonious fit, and Incremental fit are the three categories of fit indices that have been reported in this study as recommended by Awang (2016) to check the model fit as shown in Table 4.

Table 4: Model fit summary for the measurement model

Name of category	Name of index	Abbreviation	Index value	Acceptable value
Parsimonious fit	Chi-Square /Degree of Freedom	CMIN/DF	2.278	≤ 3.0
Absolute fit	Goodness of Fit Index	GFI	0.959	≥ 0.95
	Root Mean Square Error of Approximation	RMSEA	0.057	≤ 0.06
Incremental fit	Comparative Fit Index	CFI	0.976	≥ 0.95
	Tucker Lewis Index	TLI	0.966	≥ 0.95
	Normed Fit Index	NFI	0.959	≥ 0.95
	Incremental Fit Index	IFI	0.977	≥ 0.90
	Relative Fit Index	RFI	0.941	≥ 0.90

Source: Researcher's computation, 2024

Reliability and validity

After the CFA is completed, the reliability and validity of the measurement model are required before making the structural model. Internal reliability using Cronbach's alpha and construct reliability using CR have been evaluated to check the reliability of the measurement model. As per Table 3, both Cronbach's alpha and construct reliability (CR) for the four constructs are more than the threshold of 0.7 as recommended by Hair et al (2010).

The validity of the measurement model has been analyzed using convergent validity ($AVE > 0.5$), constructs validity (Fitness Indexes), and discriminant validity (Fornell-Lacker criterion) as shown in Tables 3, 4, and 5 respectively. The average variance extraction (AVE) used to calculate the convergent validity is more than 0.5 for all the constructs. Table 5 presents the discriminant validity with the help of the Fornell-Larcker criterion which is a widely used method in CB-SEM. The diagonal bold values are the square root of AVE for each construct and discriminant validity is confirmed when the square root of AVE is higher than the other values in the rows and columns which represents the correlations among the respective constructs (Awang, 2016).

Table 5 – Discriminant validity

Constructs	Saving literacy	Investment literacy	Debt literacy	Financial Sustainability of microenterprise
Saving literacy	0.773			
Investment literacy	0.542	0.829		
Debt literacy	0.517	0.668	0.763	
Financial Sustainability of microenterprise	0.577	0.65	0.758	0.848

Source: Researcher's computation, 2024

Normality and Multicollinearity

After assessing the model fit indices of the measurement model, the normality of the data must be examined before modeling the structural model (Awang, 2016). Jarque- Bera test has been used to confirm the normality. The null hypothesis assumes that the data is normally distributed. As shown in Table 6, the p-value of all items of the four constructs are higher than the significance level of 0.05, we accept the null hypothesis. Therefore, we infer that the data is normally distributed.

Table 6: Normality Test

Saving Literacy		Investment Literacy		Debt Literacy		Financial Sustainability of Microenterprises	
Items	P-value	Items	P-value	Items	P-value	Items	P-value
SL1	0.586	IL1	0.273	DL1	0.413	FSM1	0.097
SL2	0.084	IL2	0.162	DL2	0.078	FSM2	0.107
SL3	0.134	IL3	0.270	DL3	0.241	FSM3	0.073

Source: Researcher's computation, 2024

Variance Inflation Factor (VIF) and Tolerance values have been computed to detect multicollinearity between the independent and the dependent variables. As per Table 7, all the VIF values are below the threshold limit of 5 and the tolerance values are above 0.2 indicating clearly that there is no multicollinearity.

Table 7: Multicollinearity

Variables	FSM1		FSM2		FSM3	
	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance
SL1	1.912	.523	1.912	.523	1.912	.523
SL2	1.982	.505	1.982	.505	1.982	.505
SL3	1.876	.533	1.876	.533	1.876	.533
IL1	2.299	.435	2.299	.435	2.299	.435
IL2	2.618	.382	2.618	.382	2.618	.382
IL3	1.983	.504	1.983	.504	1.983	.504
DL1	1.918	.521	1.918	.521	1.918	0.521
DL2	2.083	.480	2.083	.480	2.083	0.480
DL3	1.765	.567	1.765	.567	1.765	0.567

Source: Researcher's computation, 2024

Path Analysis

Finally, the structural model was constructed as shown in Figure 2. The fitness indices shown in Table 8, clearly indicate that the proposed model fits well as CMIN/DF is 2.278 and RMSEA is 0.057 which is less than the acceptable value and all the other indices like GFI, CFI, TLI, IFI, and RFI which are reported are more than the acceptance criteria.

Figure 2: The Structural Model

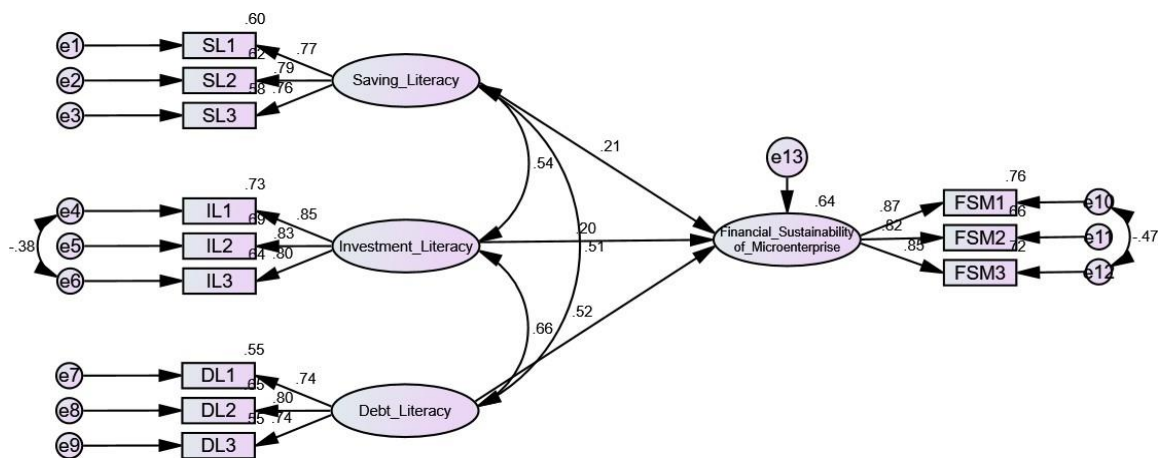


Table 8: Model fit summary for the structural model

Name of category	Name of index	Abbreviation	Value for the model	Acceptable value
Parsimonious fit	Chi-Square /Degree of Freedom	CMIN/DF	2.278	≤ 3.0
Absolute fit	Goodness of Fit Index Root Mean Square Error of Approximation	GFI RMSEA	0.959 0.057	≥ 0.95 ≤ 0.06
Incremental fit	Comparative Fit Index Tucker Lewis Index Normed Fit Index Incremental Fit Index Relative Fit Index	CFI TLI NFI IFI RFI	0.976 0.966 0.959 0.977 0.941	≥ 0.95 ≥ 0.95 ≥ 0.95 ≥ 0.90 ≥ 0.90

Source: Researcher's computation, 2024

Table 9: Hypothesis results

Hypothesis	Estimates	P-value	Results
H1: Saving Literacy $\rightarrow$ Financial Sustainability of Microenterprise	0.207	***	Accepted
H2: Investment Literacy $\rightarrow$ Financial Sustainability of Microenterprise	0.195	0.001	Accepted
H3: Debt Literacy $\rightarrow$ Financial Sustainability of Microenterprise	0.523	***	Accepted

Source: Researcher's computation, 2024

Table 9 shows the hypothesis results which state that the p-value for all three hypotheses of the study is below 0.05 level of significance. Hence, we can infer that all three hypotheses are accepted which means that saving literacy, investment literacy, and debt literacy have a significant influence on the financial sustainability of microenterprises.

Findings

Three hypotheses were formulated to test the impact of financial literacy of micro-entrepreneurs on the financial sustainability of microenterprises. Based on the data, the financial literacy of micro-entrepreneurs most certainly has a strong impact on the financial sustainability of microenterprises as all the three components used to measure financial literacy, namely, saving literacy, investment literacy, and debt literacy showed a positive effect on financial sustainability. Business owners with more financial literacy had a greater likelihood of successfully running a business for a long time. They were more satisfied with the growth of their business, had sufficient working capital, and had better financial position.

The following results were gathered after testing the three hypotheses:

- i. The study accepts the first hypothesis (H_1) by indicating that saving literacy has a significant impact on the financial sustainability of microenterprises as the p-value is below 0.05 level of significance. The basis of saving literacy is budgeting or creating strategies for dividing the income into spending, savings, and investing. The data revealed that all microenterprise owners had a bank savings account and the majority of the owners created a budget to allocate their income. They set aside emergency funds in case of business uncertainties and saved regularly. Individuals with a good understanding of interest rates are capable of making wise financial decisions and the data reveals that the owners did know the interest rates and compared them before opening a bank account. Regularly setting aside money and maintaining a separate business fund helped the owners meet their expenses, pay off debts on time, and run their business smoothly. Realizing the value of starting to save early and the power of the compounding effect could assist in achieving long-term financial goals.
- ii. The study confirms the second hypothesis (H_2) by revealing that investment literacy also positively influenced the financial sustainability of microenterprises as the p-value is 0.002 which is below the significance level. A business owner who has an understanding of different types of investment was able to

make smart investment plans which improved their financial position. This financial freedom gave them a sense of security as selling an investment or the profits generated from the investments could help their business survive in uncertain times or serve as a second income stream for the business when the cash flow is low. The data revealed that the microenterprise owners possessed awareness about the importance of investing their money but only had an idea about limited investment options. This may be due to the lack of proper knowledge about the new financial products which might seem complex. They mostly invested their extra money in fixed deposits, recurring deposits, mutual funds, life insurance schemes, gold, and local schemes. Only limited owners knew stock markets and invested in shares, stocks, bonds, etc. Nevertheless, the microenterprise owner did invest their money which could serve as an effective way to maintain the financial sustainability of their business.

- iii. The study confirms the third hypothesis (H_3) also by indicating that debt literacy has a statistically significant impact on the financial sustainability of microenterprises as the p-value is below the significance level. Understanding the terms and conditions, interest rates, and repayment options related to the debt allows the owners to make wise borrowing decisions. The majority of microenterprise owners took loans from their relatives or friends rather than the bank. Most of the owners made it a point to understand clearly the debt agreement and the interest rates. The cost and benefits of the debt were carefully scrutinized before availing the loan and the majority were able to make the repayments on time. The findings disclosed that owners who had high debt struggled to maintain their cash flow to repay the loan. Having debt literacy helped the owners avoid debt traps and prevented them from acquiring credits that could harm the financial position of the business and put the business at risk. Microenterprise owners with high levels of debt literacy usually avoid taking excessive loans and plan a budget for repayments that will reduce the cost of interest and accelerate debt payoffs.

Conclusion and policy recommendations

The research paper raised one question, ‘How is the financial sustainability of microenterprises affected by financial literacy?’ To answer this question, an attempt was made to develop a conceptual model representing three major components of financial literacy and their relationship with the financial sustainability of microenterprises. After a thorough analysis of existing literature and empirical evidence, the results demonstrated a direct positive effect of saving literacy, investment literacy, and debt literacy on the financial sustainability of microenterprises. It is apparent that financial literacy overall plays a crucial part in building, maintaining, and sustaining a business for a long time.

In today’s dynamic business landscape, only those businesses that can anticipate the changes and are willing to adapt to those changes are the ones that can survive and grow in the long run. Micro-entrepreneurs are offered several financial products and services which if used wisely can empower them and help them in driving the sustainability and growth of their business. They can thrive in the marketplace by embracing these modern financial products that can help them overcome various financial hurdles. Modern financial products offer insurance tools, digital tools, payment platforms, and financing solutions that cater to the varied requirements of micro-entrepreneurs, and by harnessing this power, micro-entrepreneurs can enhance the overall performance of their business.

Financial literacy helps micro-entrepreneurs to make better and more beneficial financial decisions, which in turn has a positive influence on the performance of the microenterprises. Having saving literacy could help micro-entrepreneurs understand the importance of saving money for the further development of their business. Similarly, investment literacy enables micro-entrepreneurs to invest their extra money in financial products so that the profit derived from the investments can be utilized for business purposes or in case of a financial emergency. Managing debts carefully can save a business from bearing huge financial losses and that can only happen if an individual possesses debt literacy. Therefore, understanding these three components of financial literacy is of utmost importance, and equipping micro-entrepreneurs with the required financial knowledge and education can assist them in fostering a thriving business that makes contributions towards the economic development of the country.

Micro-entrepreneurs who possess financial literacy are equipped to overcome financial complexities to a greater extent as they have a better understanding of saving, investing, and borrowing which subsequently helps them make knowledgeable financial decisions, efficiently allocate financial resources, and manage risks associated with the business aiding financial sustainability of the microenterprises. In conclusion, addressing financial literacy not only empowers individual businesses but also fosters inclusive growth at the grassroot level and the overall economic growth.

Some policy recommendations have been made to enhance the financial literacy of micro-entrepreneurs which are mentioned below:

- i. Awareness of the numerous modern financial products and services among micro-entrepreneurs can be improved by conducting financial education programs covering budgeting, debt management, cash flow management, and investment options through workshops and online platforms to reach a larger audience. To ensure participation and understanding, workshops can be conducted in local languages. Feedback on such programs should be taken to improve them so that they leave maximum impact.
- ii. Offering rewards to microenterprises that participate in such programs, or demonstrate sustainable growth can encourage the micro-entrepreneurs to attend the workshops.
- iii. Banks and microfinance institutions should avoid providing complex financial products and services and should simplify them to cater to the needs of micro-entrepreneurs. Documents should be written in simple language for better understanding. Also, providing small loans with affordable interest rates can help to gradually increase the confidence of micro-entrepreneurs in handling credit.

By implementing these recommendations, policymakers and development agencies can help micro-entrepreneurs understand the value of financial literacy and strengthen their business.

Scope for further studies

This research is bounded by certain limitations like small sample size, limited dimensions, and geographical limitations. Therefore, future research endeavors can include more specific components of financial literacy on a larger sample size. The long-term effects of financial literacy on the financial sustainability of microenterprises can be understood by adopting a longitudinal research design. Future studies can also investigate micro-entrepreneurs of other regions to identify similarities or differences.

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Efficiency Analysis of Indian Private Sector Banks in a Developing Economy – A Data Envelopment Analysis Approach

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Abstract

One crucial stage in the production process is evaluating performance. Measuring production efficiency of decision making units is a vital issue for economic theorists and economic policy makers. Though there are many tools available for measuring productivity efficiency, since 1978 Data Envelopment Analysis has been emerging as a new management science for the performance analysis of production units and a very powerful tool to measure the technical efficiency of the decision making units. Data Envelopment Analysis, a non-parametric methodology based on a linear programming approach provides efficiency scores for similar organizations, known as Decision Making Units (DMUs), with many inputs and outputs, and benchmarks inefficient units against peers. DEA can be described as data-oriented as it effects performance evaluations and other inferences directly from the observed data with minimal assumption. DEA evaluates efficiency of decreasing units relative to all other units with the simple restriction that all DMUs are on or below the extreme frontier. The DMUs are then ranked according to the quantity of peers. Nonetheless, ties across ranks can be settled by Andersen-Peterson's model. Applying Seiford & Zhu's requirements for infeasibility identification validates the infeasible conclusion that the super-efficiency model yields. Traditional DEA models evaluate the performance or efficiency of a particular DMU relative to other DMUs in the set including the evaluated DMU. In contrast, when a DMU under evaluation is not included in the reference set of the envelopment model, the resulting DEA models are called super-efficiency DEA Models. The findings of our empirical study, which focused on three inputs and two outputs, of Private Sector Banks in India in 2019–20 is provided. Banker, Charnes, and Cooper (BCC) model and super-efficiency models based on the variable return to scale (VRS) assumption were employed. Sensitivity analysis was also performed and the infeasibility issue was discovered and a stability region was also created.

Keywords: Data Envelopment Analysis, Private Sector Banks, Decision Making Units, BCC Model, Super-Efficiency, Infeasibility, Sensitivity Analysis, Stability Region.

Introduction

Banking is an essential part of the entire financial system. The banking industry supports economies throughout the world. The banking sector has a significant impact on the growth and development of any country's economy. India's banking sector has been essential to the country's economy, which is among the fastest-growing in the world. The Indian banking sector has been greatly impacted by recent technological developments, an increase in international investment, and regulatory adjustments.

Following a protracted and difficult past, India's banking sector is now an essential part of the nation's economy. With the adoption of new technologies, the introduction of state-of-the-art products and services, and the expansion of its reach to previously marginalised segments in society, the sector have experienced a considerable transition in recent years. Despite the many obstacles the industry must overcome, it is well-positioned to do so and grow even more. The banking industry is predicted to have a big impact on India's future economic growth and prosperity. In this industry, banks come in a wide variety of forms, including foreign, cooperative, private, and public sector banks.

Private sector banks are those in which a private firm or a group of people owns the majority of the bank's equity. They have a distinct financial system but nonetheless abide by the central bank's rules. The purpose of this article is to assess the performance of Private Sector Banks in India through the use of Data Envelopment Analysis. Data Envelopment Analysis is a non-parametric technique that is used to compare the relative effectiveness of comparable organizations, often known as Decision Making Units (DMUs). This mathematical programming technique, which is based on a linear programming issue, is a useful tool for determining how well decision-making units are working. Each decision-making unit produces the same outputs using the same inputs. By examining DMUs with many inputs and numerous outputs, DEA calculates the efficiency frontier.

Technical, scale, allocative, economical, and other types of efficiency are possible. DEA has been used by numerous researchers in the past few years to solve various real-world challenges. Numerous sectors, including business, finance, healthcare, education, and agriculture, are among those in which DEA is used in real life. Consequently, both the service and non-service sectors have found use for DEA.

Review of literature

Despite the fact that there are many other techniques for measuring productivity efficiency, Data Envelopment Analysis has emerged as a new management science for the performance analysis of production units and a very powerful tool to measure the technical efficiency of decision-making units since 1978. The extension of Operations Research, which is predicated on optimisation techniques for resource allocation issues, is Data Envelopment Analysis. The area of Data Envelopment Analysis has produced over 7000 research articles and a sizable number of books since 1957.

The concept of technical efficiency of input based on disposability criterion states that "the vector of inputs is technically efficient if and only if increasing any output or reducing any input is achievable only by increasing some other input or decreasing some other output" (Koopman, 1951). Radial measure is a word used to describe a technical efficiency measure expressed in terms of the highest proportionate expansion of all output or decrease of all variable inputs that is conceivable (Debreu, 1951).

There has been a significant advancement in the field of measuring productive efficiency. Development shifted to concentrate on the several efficiencies referred to as "scale," "allocative," and "technical" (Farrel, 1957). Thus, the series of technical efficiency laid the groundwork for the study of frontier analysis. (Farrel, 1957; Debréu, 1951).

A linear fractional programming technique with a mathematical foundation was developed and the first thorough analysis of DEA was completed (Charnes and Cooper, 1962). In the case of multiple outputs, an efficient linear programming-based computer process based on Farrel's ideas was created for a variety of Technical Efficiency issues (Bressler, 1966; Boles, 1966; Seitz, 1966; Sitorus, 1966).

The production efficiency metric, which Farrel initially presented in 1957, was expanded upon by the development of the basic DEA model (Charnes, Cooper, and Rhodes, 1978). This model, called the CCR Model, is predicated on the Constant Returns to Scale assumption (CRS). The recommended model (CCR Model) provides an efficiency measure of each decision making unit in the sample that maximises the ratio of weighted outputs to weighted inputs, subject to the limitations that the similar ratio must be less than or equal to unity for all DMUs.

The Variable Returns to Scale assumption (VRS) is supported by the expanded CCR Model (Banker, Charnes, and Cooper, 1984). The addition of a new independent variable by Banker et al. allows one to determine whether operations are conducted in regions of expanding, constant, or diminishing returns to scale in this model. This model provides estimates of the technical and scale efficiency of each sample decision-making unit with respect to the efficiency frontier.

A parametric method-based methodology for assessing effective units and enabling comparison in Data Envelopment Analysis was developed (Anderson and Peterson, 1993). The use of super-efficiency in DEA sensitivity analysis was proposed (Zhu, 2001). Additionally, this work establishes the sufficient and necessary requirements to maintain the same efficiency classification even when data variation is applied to all DMUs.

Research was carried out to evaluate the efficiency of municipal water supply systems using Data Envelopment Analysis (AbuSerriya, Hamed and Agha, 2023). The use of Data Envelopment Analysis is illustrated by evaluating the relative financial strength of thirteen financial firms by benchmarking the financial ratios of a firm against its peers (Malhotra, Malhotra and Lafond, 2009).

An approach grounded on DEA was employed to assess and prioritise the achievements of Academy Award winners for Best Original Score between 1990 and 2016 (Asadpour and Shirouyehzad, 2019). In the banking sector, Data Envelopment Analysis was utilised to evaluate the operational efficacy of 14 saving bank branches (Sherman and Gold, 1985). The performance of the banking sector in the US and a few European countries was also investigated using Data Envelopment Analysis (Pastor, Perez, and Quesada, 1997). The efficiency of 750 selected European banks was examined using an intermediation approach (Casu and Molyneux, 2003). The efficiency of the Turkish banking sector was assessed using an interval DEA approach (Budak and Erpolat, 2013) and the results showed that interval DEA methods yield more selective results than DEA.

Efficiency estimates for Indian public sector banks' costs, revenues, and profits in 2015–2016 were evaluated using the VRS assumption (Jayarani and Prakash, 2017). Using Data Envelopment Analysis, another study

(Khurana and Khosla, 2019) looks at technical efficiency and it correlates with regard to the banking sector in India between 1995 and 2016. 94 public, private, foreign, and small financial commercial banks in India were evaluated for technical efficiency in 2019 using Data Envelopment Analysis (DEA), and the Tobit regression method was used to assess the factors that influence technical efficiency (Lakshmanasamy, 2021).

Objective of the study

After the liberalization in 1991, a large no. of private sector banks came into existence. Currently, there are 22 private sector banks. Unlike public sector banks, these banks are not owned by the government but by individuals or private corporations. According to the consolidated balance sheet of scheduled banks, 32.8 percent of the total assets of the scheduled commercial banks pertain to private sector banks as of March 31, 2021. The above facts and figures motivated the author to carry out the performance analysis of private sector banks in India.

In this article, an attempt is made to find the efficiency evaluation of Private Sector Banks in India for the period 2019-20 through basic models of DEA. Sensitivity Analysis also has been carried out followed by construction of stability region.

Methodology

Banker Charnes and Cooper (BCC) Model

Banker, Charnes and Cooper (1984) proposed a model with convexity constraint which permits variable return to scale (VRS) assumption. This model is generally known as input oriented BCC DEA Model and is presented below.

Assume that there are n units each consuming m inputs to produce s outputs. Let y_{rj} denote the level of the r th output ($r = 1, 2, \dots, s$) from unit j ($j = 1, 2, \dots, n$) and x_{ij} denotes the level of the i th input ($i = 1, 2, \dots, m$) to the j th unit.

Model I : BCC Input Oriented DEA Model

$$\theta^* = \min \theta$$

Subject to

$$\sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{j=1}^n \lambda_j y_{rj} \geq y_{ro} \text{ for } r = 1, 2, \dots, s$$

$$\sum_{j=1}^n \lambda_j = 1$$

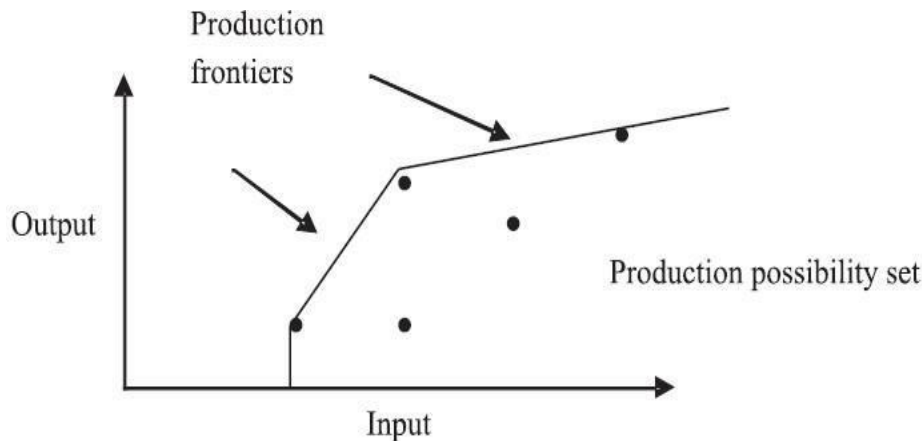
$$\lambda_j \geq 0 \text{ for } j = 1, 2, \dots, n$$

This model is termed as envelopment version and it obtains efficiency score (θ^*) and weights (λ) for each DMU. The variable θ , which appears in the objective function, represent the amount of proportional reduction applied to all inputs of evaluated DMU to improve its efficiency. It may be noted that the simultaneous reduction of all inputs results in a radial movement towards the envelopment surface. The evaluated DMU (DMU_o) is said to be efficient if

$$(i) \quad \theta^* = 1, \lambda_j = 1 \text{ for } j = o \text{ and } \lambda_j = 0 \text{ for } j \neq o$$

$$(ii) \quad \text{All slacks are zero.}$$

If $0 < \theta^* < 1$, it indicates inefficiency. BCC Model is similar to the CCR Model except for the convexity constraint $\sum_{j=1}^n \lambda_j = 1$. This convexity constraint ensures the piecewise linear approximation to the efficiency frontier and concave characteristics which leads to VRS characterization. These aspects are pictorially represented as follows



Production Frontier of the BCC Model

The above model is a primal one and its dual known as BCC output maximization is given below.

Model II : BCC Output Maximization Model

Here, Banker et al (1984) introduced a new separate variable (u_0) in the objective function which admits VRS characterization. This variable u_0 identifies whether the operations were conducted in the region of increasing, constant or decreasing return to scale in case of multiple input and multiple output scenario.

$$\max_{u,v} Z_o(u,v) = \sum_{r=1}^s u_r y_{ro} + u_0$$

Subject to

$$\sum_{i=1}^m v_i x_{io} = 1$$

$$\sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} + u_0 \leq 0 \text{ for } j = 1, 2, \dots, n$$

$$v_i \geq \varepsilon \text{ for } i = 1, 2, \dots, m$$

$$u_r \geq \varepsilon \text{ for } r = 1, 2, \dots, s$$

$$u_0 \text{ free in sign}$$

The optimal solution of this model (Z_o^*, u_r and v_i) represents the efficiency scores, weights of outputs and inputs respectively for the evaluated DMU_o. DMU_o is efficient if and only if $Z_o^* = \max Z_o = 1$, otherwise it is inefficient. Next, BCC developed output oriented DEA Model (envelopment version) and the same is given below.

Model III : BCC Output Oriented DEA Model

$$\phi^* = \max \phi$$

Subject to

$$\sum_{j=1}^n \lambda_j x_{ij} \leq \phi x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{j=1}^n \lambda_j y_{rj} \geq \phi y_{ro} \text{ for } r = 1, 2, \dots, s$$

$$\sum_{j=1}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j = 1, 2, \dots, n$$

This model results in efficiency score (ϕ^*) and weights (λ) for each DMU. The above model maximizes on ϕ to achieve proportional output augmentation with $\phi = 1$ indicating efficiency and $\phi > 1$ indicating an extent of radial inefficiency related to the best practice DMU included in the sample.

Super-Efficiency Models

It is well established that the fundamental DEA methodology—CCR and BCC—is an extremely effective instrument for evaluating the effectiveness or performance of comparable organizations. However, DEA displays many units as efficient in the situation of a high number of inputs and outputs because of the restriction on the efficiency score that $\phi^* = 1$ in output oriented. As a result, there may be ties in rankings among the DMUs in the sample taken into consideration for the study when we attempt to rate the DMUs based on the peer summary. The idea of super-efficiency was presented in order to tackle this problem. Conventional DEA models assess a DMU's effectiveness or performance in comparison to other DMUs in the set that includes the DMU under evaluation. On the other hand, the resultant DEA models are referred to as super-efficiency DEA Models when the DMU being evaluated is not part of the envelopment model's reference set.

VRS Super-Efficiency DEA Models

Seiford and Zhu (2002) proposed VRS SE DEA model based on Anderson and Peterson (1993) SE DEA model in respect of input oriented and output oriented and are presented below.

Model IV : VRS SE DEA Model (Input Oriented)

$$\min \theta^{SE}$$

Subject to

$$\sum_{j=1, j \neq o}^n \lambda_j x_{ij} \leq \theta^{SE} x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{j=1, j \neq o}^n \lambda_j y_{rj} \geq y_{ro} \text{ for } r = 1, 2, \dots, s$$

$$\sum_{j=1, j \neq o}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j \neq o$$

This model yields SE Scores of the evaluated DMU and weights to all other DMUs included in the set. The SE Scores categorize (Charnes, Cooper and Thrall, 1991) the set of DMUs into four groups namely.

- (i) E: set of extreme efficient DMUs ($\theta^{SE*} > 1$)
- (ii) E': set of efficient DMUs that are not extreme points ($\theta^{SE*} = 1$)
- (iii) F: set of weakly efficient DMUs ($\theta^{SE*} = 1$ but with non – zero slacks)
- (iv) N: set of inefficient DMU ($\theta^{SE*} < 1$)

The new facet could be formed by the reference set (which may include F and N) corresponding to each extreme efficient DMU in the set E. This new facet represents min input combination used to produce the same level of output

Model V : VRS SE DEA Model (Output Oriented)

max Φ^{SE}

Subject to

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j x_{ij} \leq x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j y_{rj} \geq \Phi^{SE} y_{ro} \text{ for } r = 1, 2, \dots, s$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j \neq o$$

The solution of the model yields SE Scores of the evaluated DMU and weights to all other DMUs in the sample. The SE Scores categorize (Charnes, Cooper and Thrall, 1991) the set of DMUs into four groups namely.

- (i) E: set of extreme efficient DMUs ($\theta^{SE*} > 1$)
- (ii) E': set of efficient DMUs that are not extreme points ($\theta^{SE*} = 1$)
- (iii) F: set of weakly efficient DMUs ($\theta^{SE*} = 1$ but with non – zero slacks)
- (iv) N: set of inefficient DMU ($\theta^{SE*} < 1$)

The new facet formed by the reference set represent that no other DMU produces the max output with the given input combinations. It may be noted that the frontier line will not alter if the inefficient and weak efficient DMUs are excluded from the new facet.

Problem of Infeasibility

It is known that the evaluated DMU is excluded from the reference set in the SE DEA Models and it causes the problem of infeasibility. A necessary and sufficient condition says that infeasibility occurs in the case of extreme efficient DMUs. Also, it may be noted that extreme efficient DMUs have either feasible or infeasible solution. Infeasibility may arise in CRS SE input oriented DEA Model with the necessary and sufficient condition in case of occurrence of certain patterns of zero data in inputs and outputs (Zhu, 1996). But CRS SE output oriented DEA Model does not encounter the problem of infeasibility. The problem of infeasibility mainly arises in VRS SE DEA Model, because of its scale assumption (VRS). Chen and Liang (2011) stated the following theorem which explains the sufficient condition for infeasibility in VRS SE DEA Model.

Theorem 1: Statement

A sufficient but not necessary condition for infeasibility of the **input-oriented** VRS SE models is that there exists at least one output that has a value for the evaluated DMU_o greater than the values of any other DMUs.

Theorem 2: Statement

A sufficient but not necessary condition for infeasibility of the **output-oriented** VRS SE models is that there exists at least one input that has a value for the evaluated DMU_o greater than the values of any other DMUs.

It may be noted that efficient DMU under standard BCC DEA model is either extreme efficient or infeasible in VRS SE Model. Lee, Chu and Zhu (2011) proposed the following theorems for the identification of infeasibility that arises in input oriented and output oriented models

Theorem 3: Statement

The input-oriented super-efficiency VRS model is infeasible if and only if $g^* < 1$ where g^* is the optimal value to

$$g^* = \max g$$

Subject to

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j y_{rj} \geq g y_{ro} \text{ for } r = 1, 2, \dots, s$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j \neq o$$

Theorem 4: Statement

The output-oriented super-efficiency VRS model is infeasible if and only if $h^* > 1$ where h^* is the optimal value to

$$h^* = \min h$$

Subject to

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j x_{ij} \leq h x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j \neq o$$

Efficiency Sensitivity Analysis

Sensitivity analysis plays a vital role in the performance evaluation through Data Envelopment Analysis. In recent years, many researchers have studied efficiency sensitivity to perturbations in the data which is an important issue in DEA. Initially Charnes, Cooper, Golany, Seiford and Stutz (1985) studied sensitivity analysis that examines the change in single output. Further, Ahn and Seiford (1993) focussed on sensitivity of DEA results to the variable and model selection. Besides, some studies on sensitivity analysis were developed for the determination of range within which the variation is possible for any DMU. Degrees of freedom approach, algorithmic approach, metric approach and multiplier model approach are some more avenues for studying sensitivity analysis in DEA. It may be noted that super-efficiency DEA is another approach for studying DEA Sensitivity Analysis and it allows perturbations in data to preserve efficiency classification in the following cases.

- (i) either in any input or any output in test DMU.
- (ii) either in any input or any output in test DMU and remaining DMUs
- (iii) any specific inputs and outputs in test DMU and remaining DMUs.

In this study, the author attempted DEA sensitivity analysis based on SE DEA model (Zhu 1996), in the case of data perturbations to output only in test DMU.

It is obvious that increasing any output or decreasing any input in the test DMU, the application of sensitivity analysis to perturbations in the data does not worsen the efficiency classification. So sensitivity analysis may be suggested to perform in the situation where decreasing any output or increasing any input alter the efficiency classification. Below are the forms, which may be considered for proportional increase of inputs or proportional decrease of outputs.

$$\hat{x}_{io} = \beta_i x_{io}; \quad \beta_i \geq 1, i = 1, 2, \dots, m \quad (3.1)$$

$$\hat{y}_{ro} = \alpha_r y_{ro}; \quad 0 < \alpha_r \leq 1, r = 1, 2, \dots, s \quad (3.2)$$

where x_{io} ($i = 1, 2, \dots, m$) and y_{ro} ($r = 1, 2, \dots, s$) are the inputs and outputs of the specific extreme efficient DMU_o respectively. Zhu (2003) stated that any increase of input or decrease of output will definitely change the status of DMUs in the efficient set E' to the inefficient set N . The DMUs in the weak efficient set F retain their same status irrespective of the amount of inputs increased or the amount of output decreased. So the sensitivity issues in the set E or F can be ignored. Thus, only the set of extreme efficient DMUs (E) would be subjected for sensitivity analysis. In this context stability region could be constructed for every extreme efficient DMU to maintain its efficiency status.

kth Specific DEA Models

Seiford and Zhu (1998) suggested VRS kth specific DEA models in both orientation to construct the stability region for the extreme efficient DMUs and the same is listed below.

Model VI : VRS kth Specific Output Oriented DEA Model

max α_k for each $k = 1, 2, \dots, s$

Subject to

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j y_{rj} \geq \alpha_k^o y_{ro}$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j y_{rj} \geq y_{ro} \text{ for } r \neq k$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j x_{ij} \leq x_{io} \text{ for } i = 1, 2, \dots, m$$

$$\sum_{\substack{j=1 \\ j \neq o}}^n \lambda_j = 1$$

$$\lambda_j \geq 0 \text{ for } j \neq o$$

For the above model, x_{ij} ($i = 1, 2, \dots, m$) and y_{rj} ($r = 1, 2, \dots, s$) represent the i^{th} input and r^{th} output of DMU_j ($j = 1, 2, \dots, n$) respectively. Here the optimal values (α_k^* , $k = 1, 2, \dots, s$) of the model provide hypothetical frontier points. This frontier points from the output stability region that allows possible output decrease in each individual output for the observed DMU_o. Thus DMU_o could preserve its status in the same efficiency classification keeping all other outputs constant. Zhu (2003) define the following output stability region.

Definition

A region of allowable output decrease is called an Output Stability Region (OSR) if and only if DMU_o remains efficient after such decreases occur.

By solving the above models for each extreme efficient DMU, the solution obtained may be feasible or infeasible. Output stability region is of the form $\alpha_k^o < \alpha_k \leq 1$ in case of feasibility and it allows maximum α_k^o times of decrease in specific k th output from current level to preserve same efficiency classification. α_k , the adjusted factor, is an arbitrary value and it lies within the output stability region ($\alpha_k^o < \alpha_k \leq 1$). In the case of infeasibility, the output stability region is of the form $\alpha_k \leq 1$. The same efficiency classification can also be preserved by any value lesser than or equal to one multiplied with the specific k th output. Thus the OSR is of the closed form in case of feasibility and has no lower limit in case of infeasibility for data variation.

Zhu (2005) explains infeasibility and stability for the k th specific model through the following theorems.

Theorem 6: Statement

For an efficient DMU_o, a decrease of the k th output only, Model VI is infeasible, if and only if the amount of k th output of DMU_o can be decreased without limitation while maintaining the efficiency of DMU_o.

The above discussions clearly explain the application of the data variation to the test DMU for a specific output.

Data structure

The Department of Research and Statistics, Indian Banks' Association, Mumbai, published reports on the Performance Highlights of Private Sector Banks 2019–20. These reports contain the data that was taken into consideration for analysis. There were 22 private sector banks in India in 2019–20, and each one is taken into account for the performance analysis when referring to the 2019–20 research period. Every bank is seen as a decision-making unit. Here, the author takes into account five input and three output variables, all of which have been carefully chosen based on earlier research on banking performance.

BCC output-oriented DEA Models are used in this study to estimate the technical efficiency in order to evaluate the performance of Private Sector Banks operating in India. After carefully reviewing a number of previous studies pertaining to the performance in the national and international banking sectors, the author chose the input and output variables for the current investigation. According to the author, the production process greatly benefits from the careful selection of variables in this study, including input and output. Moreover, efforts are undertaken to verify and consistently test the data points. The Private Sector Banks (DMUs) considered for this study are listed in the following table.

Table 1: List of Private Sector Banks

S.No.	Name of the Bank	DMU	S.No.	Name of the Bank	DMU
1.	City Union Bank Ltd.	DMU 1	12.	The South Indian Bank Ltd.	DMU 12
2.	Tamilnad Mercantile Bank Ltd.	DMU 2	13.	Axis Bank Ltd.	DMU 13
3.	The Catholic Syrian Bank Ltd.	DMU 3	14.	DCB Bank Ltd.	DMU 14
4.	Dhanlaxmi Bank Ltd.	DMU 4	15.	HDFC Bank Ltd.	DMU 15
5.	The Federal Bank Ltd.	DMU 5	16.	ICICI Bank Ltd.	DMU 16
6.	The Jammu & Kashmir Bank Ltd.	DMU 6	17.	Indusind Bank Ltd.	DMU 17
7.	The Karnataka Bank Ltd.	DMU 7	18.	Kotak Mahindra Bank Ltd.	DMU 18
8.	The Karur Vysya Bank Ltd.	DMU 8	19.	Yes Bank Ltd.	DMU 19
9.	The Lakshmi Vilas Bank Ltd.	DMU 9	20.	Bandhan Bank	DMU 20
10.	The Nainital Bank Ltd.	DMU 10	21.	IDFC First Bank	DMU 21
11.	RBL Bank	DMU 11	22.	IDBI Bank Ltd.	DMU 22

The input and output variables selected in this study for the Private Sector Banks is listed below.

Table 2: Input Variables

S.No.	Input Variables	Units	Notation
1.	Deposits	Amount in Crores	IP1
2.	Fixed Assets	Amount in Crores	IP2
3.	Operating Expenses	Amount in Crores	IP3
4.	Staff	Number of Persons	IP4
5.	Paid-up capital	Amount in Crores	IP5

Table 3: Output Variables

S.No.	Output Variables	Units	Notation
1.	Total Income	Amount in Crores	OP1
2.	Investments	Amount in Crores	OP2
3.	Loans & Advances	Amount in Crores	OP3

This makes up the data matrix, which serves as the study's foundation. Three output variables and five input variables make up the data structure used in this investigation. A few statistical measures, including Mean, Minimum, Maximum, Range, and Standard Deviation of various input and output variables for Private Sector Banks, are computed and displayed in the following table in order to provide an overview of the features of this data set.

Table 4: Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Deposits	22	1139822.86	7679.43	1147502.29	189047.4341	290243.41278
Fixed Assets	22	8369.01	41.28	8410.29	1738.3014	2428.54903
Operating Expenses	22	30535.10	162.43	30697.53	5741.8073	7837.33361
Staff	22	116000.00	971.00	116971.00	25246.5909	32353.88556
Paid-up capital	22	10309.23	71.36	10380.59	1221.1823	2317.51300
Total Income	22	137345.78	727.69	138073.47	24820.0518	34837.22436
Investments	22	390150.44	1676.22	391826.66	58774.1441	94603.08749
Loans & Advances	22	989873.90	3828.98	993702.88	164726.4636	250485.82986

In the process of understanding this data set better, the author is interested in further examining the relationship between input and output variables. In view of this, the author attempted correlation analysis between the input and output variables and the results are outlined below.

Table 5: Correlation Analysis

Input Variables	Output Variables			
		Total Income	Investments	Loans & Advances
Deposits	Pearson Correlation	0.984	0.989	0.995
	Sig. (2-tailed)	0.000	0.000	0.000
	N	22	22	22
Fixed Assets	Pearson Correlation	0.679	0.701	0.662
	Sig. (2-tailed)	0.001	0.000	0.001
	N	22	22	22
Operating Expenses	Pearson Correlation	0.996	0.984	0.993
	Sig. (2-tailed)	0.000	0.000	0.000
	N	22	22	22
Staff	Pearson Correlation	0.962	0.944	0.963
	Sig. (2-tailed)	0.000	0.000	0.000
	N	22	22	22
Paid-up capital	Pearson Correlation	0.074	0.097	0.015
	Sig. (2-tailed)	0.742	0.668	0.948
	N	22	22	22

From Table 5, it may be observed that the input variable considered, except for Paid-up Capital, have a significant relationship with the selected output variable. Though one input variable does not show significant relationship with the output variables, Paid-up Capital is practically considered as an important input variable in Banking Sectors and plays a vital role in Data Envelopment Analysis and has thus been considered for the study.

Empirical investigation

BCC – Efficiency Scores and Peer Weights

The application of BCC output oriented Model to Private Sector Bank data yielded the following results.

Table 6: Efficiency Scores and Peer Weights – BCC Model

DMU	Efficiency Score	Reference DMU Weights				
DMU 1	1	$\lambda_1 = 1$				
DMU 2	1	$\lambda_2 = 1$				
DMU 3	1	$\lambda_3 = 1$				
DMU 4	1	$\lambda_4 = 1$				
DMU 5	1	$\lambda_5 = 1$				
DMU 6	1	$\lambda_6 = 1$				
DMU 7	1.0702	$\lambda_1 = 0.0794$	$\lambda_{10} = 0.1225$	$\lambda_{12} = 0.7386$	$\lambda_{19} = 0.0595$	
DMU 8	1.0807	$\lambda_1 = 0.4989$	$\lambda_{10} = 0.4106$	$\lambda_{15} = 0.0200$	$\lambda_{17} = 0.0532$	$\lambda_{19} = 0.0173$
DMU 9	1.4077	$\lambda_3 = 0.1191$	$\lambda_4 = 0.7314$	$\lambda_{10} = 0.0964$	$\lambda_5 = 0.0050$	$\lambda_{19} = 0.0481$
DMU 10	1	$\lambda_{10} = 1$				
DMU 11	1	$\lambda_{11} = 1$				
DMU 12	1	$\lambda_{12} = 1$				
DMU 13	1	$\lambda_{13} = 1$				
DMU 14	1.0816	$\lambda_1 = 0.0429$	$\lambda_{10} = 0.6921$	$\lambda_9 = 0.2068$	$\lambda_{19} = 0.0582$	
DMU 15	1	$\lambda_{15} = 1$				
DMU 16	1.0642	$\lambda_4 = 0.0983$	$\lambda_{15} = 0.6483$	$\lambda_{19} = 0.2346$	$\lambda_{21} = 0.0188$	
DMU 17	1	$\lambda_{17} = 1$				
DMU 18	1.2103	$\lambda_5 = 0.0453$	$\lambda_{12} = 0.2888$	$\lambda_{15} = 0.1552$	$\lambda_{19} = 0.5107$	
DMU 19	1	$\lambda_{19} = 1$				
DMU 20	1.0127	$\lambda_2 = 0.0728$	$\lambda_5 = 0.1482$	$\lambda_{10} = 0.5144$	$\lambda_{19} = 0.2646$	
DMU 21	1	$\lambda_{21} = 1$				
DMU 22	1	$\lambda_{22} = 1$				

15 DMUs are found to be efficient whereas 7 DMUs are inefficient as portrayed by the table above. The output targets of the 7 inefficient DMUs are furnished below.

Table 7: Targets for inefficient DMUs

DMU	Name of the Banks	OP1	OP2	OP3
DMU 7	The Karnataka Bank Ltd.	9238.6017	18777.6275	60965.1248
DMU 8	The Karur Vysya Bank Ltd.	8039.2479	17033.8975	52429.8065
DMU 9	The Lakshmi Vitas Bank Ltd.	3601.0227	7578.9940	19726.1131
DMU 14	DCB Bank Ltd.	4741.7200	8373.1293	27413.2133
DMU 16	ICICI Bank Ltd.	98852.1916	265548.9630	686711.2814
DMU 18	Kotak Mahindra Bank Ltd.	44031.4998	90835.4888	265962.9847
DMU 20	Bandhan Bank	12944.8419	18491.8287	67476.4593

If the output is increased based on the above targets, efficiency could be attained. Out of the 15 efficient DMUs, 4 DMUs are categorized as weak efficient. The ranking of the remaining 11 efficient DMUs are given below.

Table 8: Ranking of DMUs

DMU	Counts	Rank
DMU 1	3	4
DMU 2	1	6
DMU 3	1	6
DMU 4	2	5
DMU 5	2	5
DMU 10	5	2
DMU 12	3	4
DMU 15	4	3
DMU 17	1	6
DMU 19	7	1
DMU 21	1	6

The table indicates that DMU19, DMU10, DMU 15 are ranked 1, 2, 3 respectively It may also be observed that tie exist in this ranking such as the tie for Rank 6 exhibited by four DMUs, namely DMU2, DMU3, DMU17 and DMU 21.

VRS Super-Efficiency Scores

Applying Model V to Private Sector Banks data, the super-efficiency score and peer weights for each DMU are obtained and listed below.

Table 9: Super-Efficiency Scores and Weights – VRS SE DEA Model

DMU	Efficiency Score	Weights for Reference DMU				
DMU 1	Infeasible					
DMU 2	0.8996	$\lambda_5 = 0.0997$	$\lambda_{10} = 0.8827$	$\lambda_{15} = 0.0077$	$\lambda_{19} = 0.0098$	
DMU 3	0.9203	$\lambda_4 = 0.5320$	$\lambda_{10} = 0.4624$	$\lambda_{15} = 0.0056$		
DMU 4	0.8957	$\lambda_{10} = 0.9722$	$\lambda_{15} = 0.0003$	$\lambda_{21} = 0.0193$	$\lambda_{22} = 0.0082$	
DMU 5	0.8357	$\lambda_{10} = 0.9007$	$\lambda_{15} = 0.0994$			
DMU 6	Infeasible					
DMU 7	1.0702	$\lambda_1 = 0.0794$	$\lambda_{10} = 0.1225$	$\lambda_{12} = 0.7386$	$\lambda_{19} = 0.0595$	
DMU 8	1.0807	$\lambda_1 = 0.4989$	$\lambda_{10} = 0.4106$	$\lambda_{15} = 0.0200$	$\lambda_{17} = 0.0532$	$\lambda_{19} = 0.0173$
DMU 9	1.4077	$\lambda_3 = 0.1191$	$\lambda_4 = 0.7314$	$\lambda_{10} = 0.0964$	$\lambda_{15} = 0.0050$	$\lambda_{19} = 0.0481$
DMU 10	Infeasibl3					
DMU 11	0.9593	$\lambda_{10} = 0.8093$	$\lambda_{15} = 0.0219$	$\lambda_{19} = 0.1674$	$\lambda_{22} = 0.0013$	
DMU 12	0.9004	$\lambda_1 = 0.3212$	$\lambda_2 = 0.4914$	$\lambda_5 = 0.1704$	$\lambda_{15} = 0.0119$	$\lambda_{19} = 0.0051$
DMU 13	0.9780	$\lambda_1 = 0.0939$	$\lambda_{12} = 0.2947$	$\lambda_{15} = 0.5253$	$\lambda_{19} = 0.0861$	
DMU 14	1.0816	$\lambda_1 = 0.0429$	$\lambda_{12} = 0.6921$	$\lambda_{12} = 0.2068$	$\lambda_{19} = 0.0582$	
DMU 15	0.3889	$\lambda_6 = 0.0325$	$\lambda_{13} = 0.9675$			
DMU 16	1.0642	$\lambda_4 = 0.0983$	$\lambda_{15} = 0.6483$	$\lambda_{19} = 0.2346$	$\lambda_{21} = 0.0188$	
DMU 17	0.8407	$\lambda_1 = 0.6390$	$\lambda_{15} = 0.1323$	$\lambda_{19} = 0.2286$		
DMU 18	1.2103	$\lambda_5 = 0.0453$	$\lambda_{12} = 0.2888$	$\lambda_{15} = 0.1552$	$\lambda_{19} = 0.5107$	
DMU 19	0.5395	$\lambda_{11} = 0.2508$	$\lambda_{15} = 0.0170$	$\lambda_{17} = 0.1803$	$\lambda_{20} = 0.1271$	$\lambda_{21} = 0.4249$
DMU 20	1.0127	$\lambda_2 = 0.0728$	$\lambda_5 = 0.1482$	$\lambda_{10} = 0.5144$	$\lambda_{19} = 0.2646$	
DMU 21	0.5896	$\lambda_4 = 0.4262$	$\lambda_{19} = 0.5738$			
DMU 22	0.7095	$\lambda_{10} = 0.8556$	$\lambda_{15} = 0.1444$			

From the above table, it may be observed that infeasible solution exists for DMU1, DMU6 and DMU10. It is also observed from the above table that there are 15 extreme efficient DMUs ($\phi^{SE*} < 1$ and includes 3 infeasible DMUs) and 7 inefficient DMUs ($\phi^{SE*} > 1$). Also, it is identified there is no efficient and weak efficient DMUs. The following table gives the new facet target for each extreme efficient DMU in respect of their reference set.

Table 10: VRS New Facet Target

DMU	OP1	OP2	OP3
DMU 2	3591.8043	8517.1049	24933.9699
DMU 3	1696.6640	4932.6921	10802.2425
DMU 4	1297.5142	3298.4877	6752.0241
DMU 5	14373.4667	40439.0116	102176.3653
DMU 11	10000.0277	17410.4887	53768.6841
DMU 12	7931.7933	18570.2399	58018.9174
DMU 13	78839.5468	216522.8874	558880.6731
DMU 15	75925.0392	152392.8688	554958.0322
DMU 17	30040.7536	67719.2731	192380.8621
DMU 19	20459.0068	43274.0950	112581.7562
DMU 21	22230.3842	26768.9722	101147.7335
DMU 22	20562.3151	58019.3249	146780.4246

The facet targets exhibits efficient stability region and to prove this, DMU2 is considered, and is presented in the following table.

Table 11: DMU2 Reference Points

Variables	Original Values	Reference Point
IP1 Deposits	36825.03	36825.03
IP2 Fixed Assets	128.46	128.46
IP3 Operating Expenses	850.91	850.91
IP4 Staff	4325	4325
IP5 Paid-up Capital	142.51	142.51
OP1 Total income	3992.53	3591.80
OP2 Investments	9467.33	8517.10
OP3 Loan & Advances	27715.8	24933.97
ϕ^{SE}	0.8996	0.9999
ϕ	1	1

It may be noted that the super-efficiency score of DMU2 remains extreme efficient if all the outputs of DMU2 are scaled down 0.8996 times proportionally with inputs unchanged. Similarly, all extreme efficient DMUs are interpreted.

Condition for Infeasibility

Seiford and Zhu (1999) stated a necessary and sufficient condition for infeasibility through which the existence of infeasibility among the DMUs considered in this study has been verified and furnished below.

Table 12: Condition for Infeasibility

DMU	Name of the Banks	$h^*(\text{infeasible test})$
DMU 1	City Union Bank Ltd.	1.0423 ($h^* > 1$)
DMU 2	Tamilnad Mercantile Bank Ltd.	0.5402
DMU 3	The Catholic Syrian Bank Ltd.	0.4863
DMU 4	Dhanlaxmi Bank Ltd	0.7043
DMU 5	The Federal Bank Ltd.	0.1921
DMU 6	The Jammu & Kashmir Bank Ltd.	1.0332 ($h^* > 1$)
DMU 7	The Karnataka Bank Ltd.	0.2464
DMU 8	The Karur Vysya Bank Ltd.	0.4711
DMU 9	The Lakshmi Vitas Bank Ltd.	0.3581
DMU 10	The National Bank Ltd.	3.9392 ($h^* > 1$)
DMU 11	RBL Bank	0.1522
DMU 12	The South Indian Bank Ltd.	0.4169
DMU 13	Axis Bank Ltd.	0.1299

DMU 14	DCB Bank Ltd.	0.2529
DMU 15	HDFC Bank Ltd.	0.1336
DMU 16	ICICI Bank Ltd.	0.0570
DMU 17	Indusind Bank Ltd.	0.1094
DMU 18	Kotak Mahindra Bank Ltd.	0.0527
DMU 19	Yes Bank Ltd.	0.0729
DMU 20	Bandhan Bank	0.1345
DMU 21	IDFC First Bank	0.1179
DMU 22	IDBI Bank Ltd.	0.0548

From the above table, it may be observed that the DMUs which are identified as infeasible under VRS SE Model satisfied the necessary and sufficient condition for infeasibility ($h^* > 1$).

Sensitivity Analysis

Sensitivity analysis is generally considered to be an important part of DEA; hence, an attempt has been made to do sensitivity analysis in the SE DEA model, specifically VRS kth particular output models. The following section presents the calculated SE scores for the VRS kth specific output DEA model.

VRS kth Specific Output DEA Model

Next, the author attempted VRS kth specific output DEA Model. The results for the various combinations of k are calculated and presented below.

Table 13: VRS kth Specific Output SE Scores

DMU	$\Phi^{SE} = \alpha_{k=\{1,2,3\}}^0$	$\alpha_{k=\{1\}}^0$	$\alpha_{k=\{2\}}^0$	$\alpha_{k=\{3\}}^0$	$\alpha_{k=\{1,2\}}^0$	$\alpha_{k=\{1,3\}}^0$	$\alpha_{k=\{2,3\}}^0$
DMU 1	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible
DMU 2	0.8996	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible
DMU 3	0.9203	Infeasible	0.9193	Infeasible	0.9193	Infeasible	0.9201
DMU 4	0.8957	Infeasible	0.8957	Infeasible	0.8957	Infeasible	0.8957
DMU 5	0.8357	Infeasible	Infeasible	0.8136	Infeasible	0.8357	0.8136
DMU 6	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible
DMU 7	1.0702	1.1783	1.2606	1.0708	1.1344	1.0708	1.0702
DMU 8	1.0807	1.1346	1.2527	1.0891	1.1181	1.0890	1.0807
DMU 9	1.4077	1.6841	1.4968	1.5725	1.4079	1.5725	1.4143
DMU 10	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible
DMU 11	0.9593	0.9401	Infeasible	Infeasible	0.9593	0.9401	Infeasible
DMU 12	0.9004	Infeasible	Infeasible	Infeasible	Infeasible	0.8716	Infeasible
DMU 13	0.9780	Infeasible	Infeasible	0.9780	Infeasible	0.9780	0.9780
DMU 14	1.0816	1.2262	1.3117	1.0842	1.1628	1.0842	1.0816
DMU 15	0.3889	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible	Infeasible
DMU 16	1.0642	1.0772	1.0725	1.0712	1.0698	1.0712	1.0642
DMU 17	0.8407	Infeasible	Infeasible	Infeasible	Infeasible	0.8407	Infeasible
DMU 18	1.2103	1.3672	1.2758	1.2207	1.2602	1.2207	1.2103
DMU 19	0.5395	Infeasible	Infeasible	Infeasible	Infeasible	0.5352	Infeasible
DMU 20	1.0127	1.0502	1.3030	1.0127	1.0502	1.0127	1.0127
DMU 21	0.5896	Infeasible	0.5896	Infeasible	0.5896	Infeasible	0.5896
DMU 22	0.7095	Infeasible	0.5605	Infeasible	0.7095	Infeasible	0.5605

The above table indicate that VRS kth specific output model reflects feasibility and infeasibility in respect of various combinations of k. A few observations are noted here.

- DMU1, DMU2, DMU6, DMU10 and DMU15 are infeasible in respect of all the kth specific output models.
- DMU17 and DMU19 are feasible with respect to the SE Model and kth specific model $\alpha_{k=\{1,3\}}^0$.
- DMU3, DMU4, DMU21 and DMU22 are feasible with respect to the models $\alpha_{k=\{2\}}^0$, $\alpha_{k=\{1,2\}}^0$ and $\alpha_{k=\{2,3\}}^0$

Further, the construction of the stability region for extreme efficient DMUs is attempted and presented below.

Table 14: VRS Output Stability Region

DMU	$\alpha_k^{\sigma}=\{1,2,3\}$	$\alpha_k^{\sigma}=\{1\}$	$\alpha_k^{\sigma}=\{2\}$	$\alpha_k^{\sigma}=\{3\}$	$\alpha_k^{\sigma}=\{1,2\}$	$\alpha_k^{\sigma}=\{1,3\}$	$\alpha_k^{\sigma}=\{2,3\}$
DMU 1	$\alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 2	$0.8996 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 3	$0.9203 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$0.9193 < \alpha_2 \leq 1$	$\alpha_3 \leq 1$	$0.9193 < \alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$0.9201 < \alpha_{2,3} \leq 1$
DMU 4	$0.8957 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$0.8957 < \alpha_2 \leq 1$	$\alpha_3 \leq 1$	$0.8957 < \alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$0.8957 < \alpha_{2,3} \leq 1$
DMU 5	$0.8357 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$0.8136 < \alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$0.8357 < \alpha_{1,3} \leq 1$	$0.8136 < \alpha_{2,3} \leq 1$
DMU 6	$\alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 10	$\alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 11	$0.9593 < \alpha_{1,2,3} \leq 1$	$0.9401 < \alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$0.9593 < \alpha_{1,2} \leq 1$	$0.9401 < \alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 12	$0.9004 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$0.8716 < \alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 13	$0.9780 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$0.9780 < \alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$0.9780 < \alpha_{1,3} \leq 1$	$0.9780 < \alpha_{2,3} \leq 1$
DMU 15	$0.3889 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 17	$0.8407 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$0.8407 < \alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 19	$0.5395 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$\alpha_2 \leq 1$	$\alpha_3 \leq 1$	$\alpha_{1,2} \leq 1$	$0.5352 < \alpha_{1,3} \leq 1$	$\alpha_{2,3} \leq 1$
DMU 21	$0.5896 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$0.5896 < \alpha_2 \leq 1$	$\alpha_3 \leq 1$	$0.5896 < \alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$0.5896 < \alpha_{2,3} \leq 1$
DMU 22	$0.7095 < \alpha_{1,2,3} \leq 1$	$\alpha_1 \leq 1$	$0.5605 < \alpha_2 \leq 1$	$\alpha_3 \leq 1$	$0.7095 < \alpha_{1,2} \leq 1$	$\alpha_{1,3} \leq 1$	$0.5605 < \alpha_{2,3} \leq 1$

Next, sensitivity analysis for DMU4 based on the stability region constructed above is displayed below.

Table 15: Sensitivity analysis for DMU4

Variable	Original Value	$\alpha_k^{\sigma}=\{1\}$	$\alpha_k^{\sigma}=\{2\}$	$\alpha_k^{\sigma}=\{3\}$	$\alpha_k^{\sigma}=\{1,2\}$	$\alpha_k^{\sigma}=\{1,3\}$	$\alpha_k^{\sigma}=\{2,3\}$
IP1	10904.07	10904.07	10904.07	10904.07	10904.07	10904.07	10904.07
IP2	213.7	213.7	213.7	213.7	213.7	213.7	213.7
IP3	324.06	324.06	324.06	324.06	324.06	324.06	324.06
IP4	1714	1714	1714	1714	1714	1714	1714
IP5	253.01	253.01	253.01	253.01	253.01	253.01	253.01
OP1	1100.44	1100.44X	1100.44	1100.44	1100.44X	1100.44X	1100.44
		0.41			0.8959	0.01	
OP2	3682.4	3682.4	3682.4	X 3682.4	3682.4	X 3682.4	3682.4
			0.8959		0.8959		0.8959
OP3	6496.1	6496.1	6496.1	6496.1X	6496.1	6496.1X	6496.1
				0.01		0.01	0.8959
Standard CRS model	1	1	1	1	1	1	1
CRS SE	ϕ^{SE}	$= \phi^{SE}$	$= \phi^{SE}$	$= \phi^{SE}$	$= \phi^{SE}$	$= \phi^{SE}$	$= \phi^{SE}$
	0.8957	0.8957	0.9998	0.8957	0.9998	0.8957	0.9998
Output Specific Model	$\alpha_k^{\sigma}=\{1,2,3\}$	$\alpha_{k=\{1\}}^0$	$\alpha_{k=\{2\}}^0$	$= \alpha_{k=\{3\}}^0$	$\alpha_{k=\{1,2\}}^0$	$\alpha_{k=\{1,3\}}^0$	$\alpha_{k=\{2,3\}}^0$
	=0.8957	Infeasible	0.9998	Infeasible	0.9998	Infeasible	0.9998

It may be observed that DMU4 is efficient in BCC Model, extreme efficient in VRS SE Model and feasible or infeasible in specific output BCC models for different combinations of k , before and after data variations. Thus OSR maintains the stability in efficiency classification.

Conclusion

The author's primary focus in this paper is the sensitivity analysis of super-efficiency DEA Models. For the purpose of empirical research, data on Private Sector Banks that are active in India through 2019–20 period were taken into consideration. There are 22 Private Sector Banks in the data structure. Every bank is regarded as a decision-making unit. Three outputs and five inputs are taken into account. To assess the technical efficiency and ranking of DMUs, the author first used the conventional DEA model and the super-efficiency DEA model. Furthermore, a sensitivity analysis is performed on the DEA results. The following is a summary and presentation of the findings from the use of different DEA models.

The use of output-oriented BCC shows that thirteen banks were operating profitably. There is a tie in the ranking of DMUs under the BCC Model because Indian Bank, Oriental Bank of Commerce, Union Bank of India, and State Bank of India all receive Rank 1 under the BCC Model. The super-efficiency DEA model is used since there are ties in the DMU ranking. Thirteen extremely efficient DMUs and five inefficient DMUs are represented in the VRS SE DEA model. It should be noted that two of the thirteen extremely efficient DMUs—Indian Bank and Punjab & Sind Bank—have an infeasible solution, which is confirmed by Zhu's (2003) infeasibility test.

VRS k th specific output model highlights some of the results are feasible and infeasible and the following observations are noted. City Union Bank Ltd., Tamilnad Mercantile Bank Ltd., The Jammu & Kashmir Ltd., The National Bank Ltd. and HDFC Bank Ltd. are infeasible in respect of all the k th specific output models. Indusind Bank Ltd. and Yes Bank Ltd. are feasible with respect to the SE Model and k th specific model $\alpha^0_{k=\{1,3\}}$. The Catholic Syrian Bank Ltd., Dhanlaxmi Bank Ltd., IDFC First Bank Ltd. and IDBI Bank Ltd. are feasible with respect to the models $\alpha^0_{k=2}$, $\alpha^0_{k=\{1,2\}}$ and $\alpha^0_{k=\{2,3\}}$. Sensitivity Analysis done on Dhanlaxmi Bank Ltd. showed that the bank is efficient in BCC Model, extreme efficient in VRS SE Model and feasible or infeasible in specific output BCC models for different combinations of k , before and after data variations. Thus OSR maintains the stability in efficiency classification.

Sensitivity analysis lends credibility to any type of financial model by testing it under many scenarios. Financial sensitivity analysis provides the analyst with a great deal of flexibility when determining the parameters for assessing the sensitivity of the dependent variables to the independent factors. Making decisions is facilitated by sensitivity analysis. Decision-makers use the model to ascertain how sensitive the outcome is to changes in specific factors. Because of this, the analysis could be useful in reaching certain conclusions and be vital in assisting the banking industry in making the best decisions.

Future scope of research

DEA may be performed in respect of Foreign Sector Banks in India. Sensitivity Analysis relating to data perturbations in both input and output could be carried out. The model due to Cook et al (2009) relating to overcoming the problem of infeasibility may also be attempted. Researchers can look into the possibility of improving and modifying current DEA methodology available in DEA literature.

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Building Customer Trust: Key Factors Influencing the Success of Incumbent Startups in E-commerce and EdTech in Kerala

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Abstract

This study examines the impact of customer trust on the success of incumbent startups in Kerala, focusing on the e-commerce and EdTech sectors. In a rapidly growing digital economy, customer trust plays a pivotal role in influencing consumer choices and fostering business success. By leveraging the established reputation and resources of their parent organizations, incumbent startups can capitalize on customer trust, which is essential for differentiation in competitive markets. This research uses primary data collected from 400 founders or senior managers of startups in Kerala, with an equal split between incumbent and non-incumbent startups in both sectors. A Logistic Regression Model is employed to assess the influence of customer satisfaction and trustworthiness on the likelihood of a startup being incubated. The findings reveal that higher customer satisfaction and perceived trustworthiness significantly increase the chances of a startup being incubated. Additionally, the results emphasize the importance of product quality, transparency, and reliable customer service in building and maintaining trust.

Keywords: Customer Trust; Incumbent Startups; E-commerce; EdTech; Startup Success;

Introduction

The startup ecosystem in India has witnessed significant growth over the past decade, fueled by technological advancements, shifting consumer behaviors, and supportive government policies. Kerala, often celebrated for its literacy rate and digital adoption, has emerged as a dynamic hub for innovation and entrepreneurship. Among the diverse types of startups, incumbent startups, which benefit from the established reputation and resources of a parent organization, hold a unique position. These startups leverage the trust and brand equity of their parent companies, offering them a competitive edge. However, trust is a double-edged sword, especially in sectors like e-commerce and EdTech, where customer reliance on digital platforms for transactions and engagement is high. Meeting customer expectations is vital, as any failure could damage trust and influence customer choice.

Kerala's startup ecosystem, supported by initiatives such as the Kerala Startup Mission (KSUM), has encouraged innovation across sectors. E-commerce and EdTech startups have grown significantly, driven by widespread internet access, increasing smartphone usage, and Kerala's progressive educational policies. Incumbent startups in these sectors face unique challenges, as their success largely depends on their ability to build and sustain customer trust. Trust is multi-layered, encircling reliability, transparency, security, and ethical practices. For incumbent startups, it serves as a crucial bridge between their parent organization's legacy and the innovative contributions they bring to the market.

Customer trust is a cornerstone of business success, particularly in a competitive digital environment where customers have numerous choices. Trust influences not only customer acquisition but also retention and loyalty. In e-commerce, trust shapes decisions around online transactions, where concerns about fraud, delivery reliability, and product quality are common.

In the EdTech sector, trust impacts the perceived value of educational services, especially in Kerala, where education is highly valued. Factors such as content quality, the credibility of certifications, and the effectiveness of teaching platforms play a critical role. For incumbent startups, building and maintaining trust is both a challenge and an opportunity to differentiate themselves in these highly competitive markets.

The focus on e-commerce and EdTech startups is particularly relevant due to their rapid growth and reliance on customer trust. Kerala's e-commerce sector has seen remarkable growth, supported by increasing internet penetration and the convenience of online shopping. Incumbent startups in this sector often benefit from the reputation and logistical capabilities of their parent organizations, helping them address common customer concerns. Similarly, the EdTech sector has gained momentum, especially after the COVID-19 pandemic, which accelerated the adoption of digital learning. Incumbent EdTech startups, often associated with reputed educational institutions or publishers, are uniquely positioned to capitalize on this trend. However, trust-related

issues such as content credibility, quality assurance, and platform reliability remain critical in influencing customer choice.

Despite the growing recognition of customer trust as a critical determinant of startup success, there is limited research that examines its impact on the performance of incumbent startups. Existing studies often generalize the role of trust across industries without delving into the unique dynamics of specific sectors or regional contexts. This study seeks to address this gap by investigating how perceived customer trust influences the choice of incumbent startups in Kerala, with a comparative focus on the e-commerce and EdTech sectors. To achieve this, a primary survey will be conducted among business founders and senior managers of startups to understand how customer trust affects their operational strategies and likelihood of success.

This research is both academically and practically significant. Academically, it contributes to the growing body of literature on trust and its role in the startup ecosystem, contributing region-specific insights into the dynamics of incumbent startups.

By focusing on Kerala's unique socio-economic and cultural context, the study bridges the gap between theory and practice. From a practical perspective, the findings will provide actionable insights for e-commerce and EdTech startups, guiding them on strategies to build and sustain customer trust. These insights will also inform policy interventions aimed at fostering trust-building mechanisms within Kerala's startup ecosystem. By analysing the effect of customer trust on the success of incumbent startups, this research aims to provide an understanding of how trust operates as a competitive advantage and a critical success factor. Ultimately, the study aspires to support startups in aligning their strategies with customer expectations, ensuring sustainable growth and market differentiation in Kerala's vibrant digital economy.

Review of Literature

The existing literature highlights the significant role of founders, investors, product markets, and management processes in determining startup performance. Founders' backgrounds, including age, prior entrepreneurial success, and industry experience, positively correlate with startup success (Azoulay et al., 2019; Gompers et al., 2010). Founders with relevant experience often inspire higher levels of trust among customers and investors (Chatterji, 2009; Agarwal et al., 2004). Personality traits like social competence and conscientiousness are also important for fostering customer trust (Baron & Markman, 2003; Zhao et al., 2010), although overconfidence can undermine this trust (Zhao et al., 2010). The composition of the founding team, particularly one with complementary skills and low conflict levels, also plays a crucial role in promoting trust within the team and among external stakeholders (Klotz et al., 2014). Regarding investors, research indicates that venture capital (VC) support is linked to faster growth and greater innovation (Hellman & Puri, 2000), with high-reputation investors boosting trust by signaling reliability. However, the involvement of larger parent companies can sometimes hinder startups' independence, affecting customer trust. The current paper builds on these insights by focusing on how the combination of parent companies and venture capital influences customer trust in incumbent startups in Kerala, a context underexplored in the literature.

In terms of product markets, studies suggest that market saturation and overconfidence can lead to high failure rates, eroding trust among customers, particularly in competitive sectors like e-commerce and EdTech (Hogarth & Karelaia, 2012; Eisenmann, 2006; Schilling, 2017). Trust is critical in crowded markets, where startups must differentiate themselves through quality assurance, transparency, and reliability. Mastrostefano et al. (2020) emphasize the importance of trust in Open Innovation for startups, which enables them to overcome resource limitations and successfully adopt external innovation. Their systematic review identifies trust as a cornerstone for fostering collaboration and ensuring startup growth. Similarly, Sussan and Acs (2021) examine the emergence and financing of fintech startups, highlighting the critical roles of trust in fostering investor confidence and collaboration. They also underscore knowledge creation as a driver of innovation and competitive advantage in the fintech sector. Further, Tessaro et al. (2024) explore the factors influencing startups' attractiveness to suppliers, focusing on the liability of newness and lack of reputation. Using a discrete choice experiment with salespeople, they identify eight factors that impact supplier preferences, emphasizing that strategic compatibility, operative excellence, and innovation enhance startup attractiveness more than for incumbents. This paper examines how incumbent startups in Kerala leverage customer trust to succeed in these competitive sectors. Management processes also play a crucial role, with lean startup principles emphasizing a customer-centric approach (Ries, 2011; Blank, 2013). Startups that prioritize customer feedback and iterative development tend to perform better (Felin et al., 2020; Camuffo et al., 2019), and this paper explores how these practices are applied in Kerala's unique startup environment. By focusing on how customer trust influences startup performance in Kerala's e-commerce and EdTech sectors, this paper fills a gap in the literature, providing intuitions for both entrepreneurs and policymakers aiming to foster sustainable startup ecosystems in emerging markets.

Data and Methods

This study investigates the impact of customer trust on startups in Kerala, focusing on the e-commerce and EdTech sectors.

Primary data were collected exclusively from 400 founders or senior managers of startups, with an equal split of 200 respondents each from incumbent and non-incumbent startups across the two sectors. The survey was designed to gather in-depth insights into trust-building strategies, challenges, and the role of customer trust in shaping business performance and customer retention. Stratified sampling was employed to ensure a balanced representation of startups operating in diverse locations across Kerala. The survey examined key variables, type of startup, perceived customer trust, and other individual and firm-related factors. To examine the factors influencing the probability of a startup being incubated, a Logistic Regression Model was employed. The dependent variable is binary, indicating whether a startup is incubated (coded as 1) or not incubated (coded as 0).

The Logit model is appropriate in this case as it estimates the probability of a binary outcome based on a set of explanatory variables. The variable of interest is customer trust. To measure customer trust, the study used customer satisfaction with platform services (measured on a 1–5 scale) and trustworthiness and quality (coded as yes = 1; no = 0). The study also included additional control variables in the model, such as access to finance (coded as yes = 1; no = 0), firm size, education of the respondents, age, gender, experience, and professional courses undertaken.

The Logit regression model equation for analysing the determinants of i start-ups can be specified as follows:

For start-up j, the Logit model can be represented as:

$$\Phi^{-1}(P(Y_{ij} = 1)) = \beta_0 + \beta_1 \text{customer\_trust}_i + \beta_2 X_i + \epsilon_{ij} \dots \dots \dots (1)$$

Where,

Φ^{-1} denotes the inverse of the cumulative distribution function of the standard normal distribution.

$P(Y_{ij}=1)$ is the probability that the start-up i is incumbent j.

customer_trust includes customer satisfaction with platform services, Trustworthiness, and quality and X_i is control variables finance access, firm size, education of the respondents, age, gender, experience, and professional course; β_j is the vector of coefficients, and ϵ_i s the error term.

Results and discussion

Table 1 provides a statistical summary of the key variables used in the study, including the dependent variable, variables of interest, and control variables. The dependent variable, indicating the type of startup (incubated = 1, non-incubated = 0), has a mean of 0.696, suggesting that approximately 69.6% of the startups in the sample are incubated.

The variables of interest, such as "Customer Satisfaction with Platform Services" and "Trustworthiness and Quality," reflect the role of trust in customer decision-making. Customer satisfaction has a mean value of 3.9 on a 5-point scale, with a standard deviation of 4.1, showing considerable variation in satisfaction levels. Similarly, "Trustworthiness and Quality" (coded as 1 = yes, 0 = no) has a mean value of 0.65, indicating that 65% of the startups are perceived as trustworthy.

Control variables highlight other factors influencing the likelihood of a startup being incubated. For instance, 78.3% of startups report having access to finance, while 81.84% of respondents have completed a professional course, demonstrating the importance of financial and professional preparedness. The average firm size is 35.73 employees, and respondents, on average, have 16.77 years of education and 15.6 years of experience, indicating a relatively skilled and experienced workforce. Interestingly, the average age of respondents is 29.38 years, and 38.4% of respondents are female, illustrating a degree of gender diversity.

Table 1: Descriptive statistics of the variables used

Variables	Mean	Std. Dev.	Min	Max
Dependent Variables				
Type of start-up (incubated=1; non-incubated=0)	0.696	0.460	0	1

Variables of interest				
Customer Satisfaction with Platform Services (1-5 scale)	3.9	4.1	1	5
Trustworthiness and quality (yes=1; no =0)	0.65	0.69	1	0
Control variables				
finance access (yes=1; no=0)	0.783	0.412	0	1
Firm size	35.734	17.58	5	99
Education of the respondents (in years)	16.774	3.872	10	22
Age (in years)	29.379	8.869	5	55
Gender (female=1; male =0)	0.384	0.487	0	1
Experience (in years)	15.604	3.605	5	22
professional course (completed=1; not completed =0)	0.8184	0.386	0	1

Source: Author's definition

The results from the logit regression model in Table 2 reveal a significant positive relationship between customer satisfaction with platform services and the likelihood of a startup being incubated. The coefficient for customer satisfaction is 0.185 in the base model and 0.81 in the full model, both significant at a 1% level. This indicates that as customer satisfaction increases, the probability of a startup being incubated rises. High customer satisfaction reflects reliability, usability, and value, which are crucial for startups to establish credibility in competitive markets like e-commerce and EdTech. This finding implies that startups must prioritize the user experience, ensure seamless interactions, and provide high-quality services to build satisfaction and increase their chances of success. Startups can leverage customer feedback mechanisms to identify pain points and refine their offerings. Additionally, investing in robust customer support and technological innovations can enhance user satisfaction, fostering trust and long-term engagement with the platform. The regression results also show that trustworthiness and quality have a significant positive impact on the likelihood of a startup being incubated. The coefficient is 0.87 in the base model and increases to 0.154 in the full model, both significant at a 5% level.

This highlights that perceived trustworthiness and product/service quality are strong determinants of customer trust. Trustworthiness encompasses ethical practices, transparency, and security, while quality ensures that offerings meet or exceed customer expectations. Startups that emphasize these attributes are more likely to be recognized for their reliability and attract both customers and investors. Startups should focus on implementing transparent practices, secure payment gateways, and quality control measures. Additionally, certifications, third-party audits, and partnerships with credible organizations can help reinforce trustworthiness and quality perception, ultimately aiding in the incubation and scaling process.

Table 2: Effect of customer trust on incubated starts up: Results of Estimated Logit Regression Models

Variable	Base model	Ful model
Variables of interest		
Customer Satisfaction with Platform Services (1-5 scale)	0.185*** (0.011)	0.813** (0.058)
Trustworthiness and quality (yes=1; no =0)	0.087** (0.051)	0.154 ** (0.080)
Control variables		
finance access (yes=1; no=0)		0.003*** (0.004)
Firm size		0.015 ** (0.019)
Education of the respondents (in years)		0.010 *** (0.009)
Age (in years)		-0.027* (0.155)
Gender (female=1; male =0)		0.001*** (0.021)
Experience (in years)		0.503*** (0.182)
professional course (completed=1; not completed =0)		0.245*** (0.009)
LR chi2(9)	125.44	116.57

	(0.000)	
Sample size	400	

Note: Parentheses show the standard error of the estimators; *** indicates significance at the 1% level; ** indicates significance at the 5% level; * indicates significance at the 10% level.

Source: Estimated from field survey data,2022

Access to finance plays a pivotal role in determining whether a startup becomes an incumbent. Startups with access to financial resources are significantly more likely to be incubated, as they can invest in infrastructure, innovation, and marketing, thereby enhancing their competitiveness. Financial access also instills trust among customers, as well-funded startups are perceived as more stable and capable of delivering consistent quality. This aligns with the finding that 78.3% of startups in the study reported having access to finance, underscoring its critical role in achieving incubated status.

The size of a firm, measured by the number of employees, positively influences the probability of being an incumbent startup. Larger firms are more likely to have robust operational frameworks, economies of scale, and the capacity to meet customer demands efficiently. A larger workforce also signals organizational stability and scalability, which are critical for gaining customer trust in competitive markets like e-commerce and EdTech. The average firm size in the sample, 35.73 employees, reflects a relatively well-established organizational structure among incubated startups.

The educational attainment of startup founders or senior managers has a significant effect on the likelihood of being an incumbent. Higher levels of education enable entrepreneurs to make informed decisions, adopt innovative practices, and implement effective strategies to build customer trust. Education also enhances credibility, which is crucial in sectors where trust is a key determinant of customer choice. The study reports an average of 16.77 years of education among respondents, emphasizing the importance of advanced educational qualifications in fostering trust and securing incubated status.

The age of respondents, which reflects their life stage and maturity, influences the probability of being an incumbent startup. Younger entrepreneurs may bring fresh perspectives and adaptability, while older entrepreneurs often have more industry experience and established networks, which are beneficial for gaining customer trust. The mean age of respondents in the study is 29.38 years, suggesting a mix of youthful innovation and early-stage professional experience among incubated startups.

Gender diversity in the leadership of startups also plays a role in shaping trust and the likelihood of being an incumbent. Female-led startups may appeal to specific customer segments by offering unique perspectives or addressing unmet needs in the market. While 38.4% of respondents in the study are female, this proportion highlights the potential for gender diversity to contribute to organizational resilience and customer trust, particularly in sectors like EdTech, where inclusivity is often valued.

The completion of professional courses significantly enhances the probability of being an incumbent startup. Such courses provide founders and managers with specialized skills, industry knowledge, and best practices that can be directly applied to building customer trust and improving service quality. With 81.84% of respondents having completed a professional course, the study underscores the importance of continuous professional development in gaining an edge in competitive startup ecosystems.

Conclusion

This study explored the critical role of customer trust in the success of incumbent startups, with a specific focus on the e-commerce and EdTech sectors in Kerala.

Through the lens of customer trust, the research highlighted how startups can leverage their parent organizations' reputations to build a solid foundation for success. The findings demonstrate that trust, in terms of customer satisfaction and perceived trustworthiness and quality, significantly influences the likelihood of a startup being incubated and succeeding in the competitive landscape of Kerala's digital economy. The empirical analysis using a logistic regression model confirmed that customer satisfaction with platform services and the perceived trustworthiness and quality of products and services are positively associated with the probability of a startup being incubated. Startups that prioritize customer experience, transparency, and quality assurance are more likely to establish strong customer trust, which in turn increases their chances of success.

This finding is particularly relevant for both e-commerce and EdTech platforms, where customer trust is pivotal for customer acquisition, retention, and long-term loyalty. Additionally, the study underscored the importance of addressing customer concerns related to platform reliability, fraud prevention, content credibility, and service

quality. The role of effective customer feedback mechanisms, robust customer support, and ethical practices in reinforcing trust cannot be overstated. As the Kerala startup ecosystem continues to grow, the implications of these findings are clear: trust is not only a competitive advantage but also a key driver of success for incumbent startups in the region.

From a policy perspective, the study's insights can inform initiatives that support startups in building customer trust. For example, fostering trust-building mechanisms, such as certifications, transparent business practices, and secure transaction systems, can contribute to a more sustainable startup ecosystem. Additionally, the research calls for further exploration into the tones of trust in different sectors and how trust dynamics evolve as startups scale. Customer trust is a cornerstone of success for incumbent startups in Kerala's rapidly growing e-commerce and EdTech sectors. By prioritizing trust-building strategies, startups can differentiate themselves in competitive markets, gain customer loyalty, and achieve sustainable growth. The study contributes to the academic understanding of the role of trust in startup success. It provides actionable insights for entrepreneurs and policymakers aiming to foster trust-driven innovation and entrepreneurship.

The study provides insights into the policy context to support startups in building customer trust, a crucial component of success in Kerala's e-commerce and EdTech sectors. Policymakers can create an environment conducive to trust by fostering trust-building mechanisms, such as certifications, transparent business practices, and secure transaction systems. Additionally, effective interventions like developing clear regulations to encourage data security, customer service, and transparency, along with the introduction of trust certification programs, would help establish a more sustainable startup ecosystem. These measures, coupled with consumer protection initiatives, would help build a trustworthy environment for both startups and consumers. For startups, building and maintaining customer trust should be a primary focus, especially in the early stages of growth. Actively seeking customer feedback, publishing regular reports on customer satisfaction and data security, and engaging in corporate social responsibility (CSR) initiatives can help strengthen trust with their customers. Startups should also innovate around the customer experience, ensuring their platforms are intuitive and reliable, and offer value beyond just products or services. These actions can improve customer loyalty, retention, and brand credibility, positioning startups for sustainable growth in competitive markets. The reinforcement of customer trust is essential for the long-term success of startups, and businesses play a key role in fostering this trust. Policymakers should create regulatory frameworks that promote transparency and consumer education, while startups should focus on transparent communication, consistent service delivery, and robust data security practices. Ethical business practices and CSR initiatives will further enhance customer trust, enabling startups to differentiate themselves and thrive in competitive markets.

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Role of Burnout between Classroom Incivility and Learning Engagement: A Study of Select Colleges of Chandigarh

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Abstract

In terms of education, India is a major player. One of the largest international networks of schools and institutions is found in India. Traditionally, education was delivered through Gurukula. The relationship between the teacher (Guru) and students (Shishya), was one of the most crucial aspects of education. The contemporary world, which raises the next generation, is undoubtedly deficient in moral and ethical principles. The study's objectives are to ascertain classroom incivility on learning engagement and role of burnout. Majority of previous scholarly studies concentrated on workplace incivility. Civility is essential these days, whether at workplace or in the classroom. Disruptions in the classroom and student incivility are becoming worse and more frequent. In the academic world, there have been many reports of uncivil behavior. This article has examined classroom incivility and learning engagement association among college students of Union Territory, Chandigarh, Northern India. Additionally, this study has investigated how burnout influences classroom incivility and learning engagement relationship. Standardized instruments were used to collect data from respondents. For hypotheses testing, descriptive statistics, correlation, structural equation modeling and mediation analysis were used. SmartPLS4 and SPSS 26 have been used for the analysis. It has been discovered that there is complete mediation between learning engagement and classroom incivility. No direct impact of classroom incivility found on learner's engagement. Additionally, research reveals no statistically significant variation between demographic variables and classroom incivility. Through social and recreational activities, the public—which includes parents, friends, relatives, educators and school officials—will be able to provide students with valuable guidance on how to change their uncivil behavior.

Keywords: Classroom incivility, Uncivil behavior, Burnout, Learning engagement

Introduction

India is making significant contributions to the field of education. Among the biggest global university networks and colleges are found in India. In the past, education was provided through Gurukula. Among the most important elements of education was the relationship between the Guru or instructor, and his Shishya or students. In the Gurukula, teaching and politeness were equally prized. Unquestionably, there are significant moral and ethical values issues in the present world, which raises the future generation (Moore, 2012).

Students' academic and intellectual growth is hampered by disrespect in the classroom, and their motivation to use critical thinking skills is decreased. They were acting impolitely in class, which caused interruptions to the learning atmosphere and student diversions.

During the 1970s, job burnout became a prominent notion that encapsulated a significant aspect of people's work experiences (Schaufeli et al., 2009). Freudenberger (1974) defined and used the term "burnout" originally.

When Maslach and her colleagues interviewed a variety of Californian human services workers, they encountered the word burnout. Emotional fatigue, depersonalization, and decreased personal accomplishment are commonly used to characterize burnout (Maslach & Jackson, 1981).

The Burnout definition 'students in the learning process, because of course stress, course load or other psychological factors, display a state of emotional exhaustion, a tendency to depersonalization, and a feeling of low personal accomplishment' given by (Yang, 2004). The subject has not only broadened to encompass workplace burnout but also in the education sector (Schaufeli et al., 2002). When burnout in teachers and undergraduate students was contrasted and examined, students' scores fell between the medium and upper ranges of the burnout scale (Rahmati, 2015). Preventive actions might be implemented if it could be determined that students are susceptible to burnout.

Literature Review

Classroom Incivility

The organizational behavior literature has extensively studied incivility during the past 20 years, specifically workplace incivility (Andersson & Pearson, 1999). Boice (1996) carried out the first study on classroom incivility at New York's State University at Stony Brook, which included over 11,000 undergraduate students and 1500 faculty members. It was discovered that at the time, there had been no empirical studies on classroom disrespect. In addition to 16 faculty members (8 junior and 8 senior), 405 students took part in his study. It was clear from his research that students weren't treating each other well. This theory has never been thoroughly investigated by researchers until his study. It was discovered that the initial few days of class were more influential in causing students to be impolite than the teacher's level of expertise in the classroom. There were differences in disruptive behavior between males and females, though. In both elementary and high school, men demonstrated more violence than women (Arbuckle & Little, 2004). Also, social norms have a big impact on classroom incivility. The results of a study illustrated how important social norms are in shaping pupils' uncivil behavior in the classroom. The findings revealed that classroom interventions centered around social norms might effectively lower incidents of misconduct (Segrist et al., 2018).

Burnout

Maslach and Jackson (1981) originally described burnout as a condition characterized by depersonalization, cynicism, and mentally exhausted. Academic burnout is mostly displayed by those who encounter more classroom incivility (Bai et al., 2020). It was believed that people in various professions, such as those in education, social work, and health care, would eventually experience burnout (Schaufeli et al., 2002).

Learning Engagement

Instructors continue to emphasize the value of positive behavior and encourage involvement from their students in class. Student grades and other learning outcomes like cognitive thinking are positively correlated with student involvement (Carini et al., 2006). It was found that learning engagement affects academic achievement (Li et al., 2019). Students that are involved in class are usually less tolerant of disrespectful behavior and are more attentive and focused. On the other side, disengaged students typically don't connect intellectually with their professors and classmates, as well as to get bored or lose interest in studying, which promotes disruptive conduct (Cicotti, 2012). To avoid buildup over time, it is imperative to deal with uncivil behavior on a daily basis (Beattie & Griffin, 2014).

Classroom Incivility and Burnout

Burnout completely mediated the association of workplace incivility with initiated workplace incivility (Loh and Loi, 2018). Customer incivility and employee incivility are highly mediated by employee burnout (Kim and Qu, 2019). Anxiety and job burnout were positively connected with workplace incivility (Shi et al., 2018). Studies had shown burnout is positively impacted by incivility (Hong et al., 2016; Taylor et al., 2017).

H1. Classroom incivility has a significant and positive impact on burnout of students in select colleges of Chandigarh.

Burnout with Learning Engagement

In order to reduce burnout or improve engagement, different intervention tactics should be used, as indicated by the divergent patterns of probable causes and consequences that affect both.

(Schaufeli & Bakker, 2004). Based on the employees' subjective health impairment and active learning, the expectations and control may be anticipated (Demerouti et al., 2001). There is negative correlation between vigor, devotion, and absorption and emotional tiredness, cynicism, and decreased professional efficacy, respectively (Uludağ and Yaratana, 2010).

H2. Burnout has a significant and negative impact on learning engagement of students in select colleges of Chandigarh.

Classroom Incivility and Learning Engagement

Disengaged students are more prone to lose interest in their studies, lack intellectual connections with teachers and peers, and behave disruptively as a result (Cicotti, 2012). Higher levels of involvement were found in supportive environments compared to uncivil ones (Giumetti et al., 2013).

H3. Classroom incivility has a significant and negative impact on learning engagement of students in select colleges of Chandigarh.

Classroom Incivility, Burnout and Learning Engagement

Burnout mediates workplace incivility and work engagement relationship, and there is no visible direct connection between work engagement and workplace incivility (Setyadi et al., 2021).

H4. Burnout mediates classroom incivility and learning engagement relationship.

Theoretical Background

Attribution Theory

A book published by Heider (1958) "The Psychology of Interpersonal Relations", which contained theories on attribution. The notion of attribution enables us to comprehend the reasons behind an action or behavior.

Engagement Theory

The engagement theory is proposed by Kearsley and Shneiderman (1998). In this theory there are three foundational pillars of engagement theory. First is relate, second is create, and third is donate.

First pillar "relate" highlights the importance of student interaction and mutual trust. Partnership and exchange can foster innovative thinking among students, facilitate effective problem-solving, and support academic perseverance all at the same time. It will be necessary to vary the study techniques used in groups because students differ in terms of intelligence, knowledge, and thinking styles. This will let everyone take advantage of the strengths of others to make up for their own weaknesses and enhance their learning.

Second principle "create" which is meant by creative activity. The information era has already commenced in our culture, and everything we encounter on a daily basis are evolving. In this case, creativity is really essential. This principle is often articulated in engagement theory through the use of "Problem Based Learning".

Third principle of engagement theory is the "donate" principle in which students can tailor their studies to not just their own needs but also those of the larger community. This helps them become more compassionate and improves their own humane traits. There are more options for students' questions about social value and meaning because they are more pragmatic in their study habits today.

Research Methodology

Sampling

As per Department of Higher Education, Chandigarh Administration 2024, the total population was 43,088 students in selected five public and six private colleges of Chandigarh, India. The data is further divided into two categories based on their education level: undergraduate (N1 =37,888) and postgraduate (N2 = 5200). The size of the population was known so in determining the size of the sample, formula given by Yamane (1967) was used.

$$n = \frac{N}{(1 + Ne^2)}$$

where, N = Population

n = Sample size

e = Margin of error

$$n = \frac{43,088}{(1 + 43,088 (0.05)^2)} = 396.32$$

To achieve the required sample size 400 participants were contacted, out of which 320 responded. Questionnaire was sent to 36 students from each selected colleges under study. After data cleaning, which involved removing outliers and addressing missing values, the final sample size was determined to be 298. Therefore, the present study includes a final analysis based on a sample of 298 participants selected randomly from the colleges of Chandigarh. There were 178 males (60%) and 120 females (40%). The sample comprised 217(73%) students of undergraduate courses and 81(27%) students of postgraduate courses.

Measures

The study involves classroom incivility as independent variable, learning engagement as dependent variable, burnout as mediator, gender and education level as demographic variables.

Cortina et al. (2001) developed twelve-item five-point Likert Workplace Incivility Scale (WIS) which is used in this study to measure classroom incivility. Cronbach's Alpha for classroom incivility was 0.93.

Schaufeli et al. (2002) developed 17 items seven-point Likert student Version (UWES-S) scale to measure learning engagement which is used in this study. The measure categorized into three dimensions vigor, dedication and absorption. 0.77 was the value of Cronbach's Alpha for learning engagement.

Schaufeli et al. (2020) developed 12 items five-point Likert burnout scale. Cronbach's Alpha for burnout was 0.82 (see Table 1).

Table 1. Measures

Variables	Likert Scale	Items	Author	Cronbach's Alpha
Classroom Incivility	Five Point	12	Cortina et al., 2001	0.93
Learning Engagement	Seven Point	17	Schaufeli et al., 2002	0.77
Burnout	Five Point	12	Schaufeli et al., 2020	0.82

Source: Author's own compilation

Research Questions

1. How do levels of classroom incivility impact student burnout in select colleges?
2. To what extent does student burnout influence the level of learning engagement of students in select colleges?
3. How does classroom incivility affect the learning engagement of students in select colleges?
4. To what degree does burnout influence the effect of classroom incivility on student learning engagement in select colleges?
5. How do demographic factors influence the perception and experience of classroom incivility in select colleges?

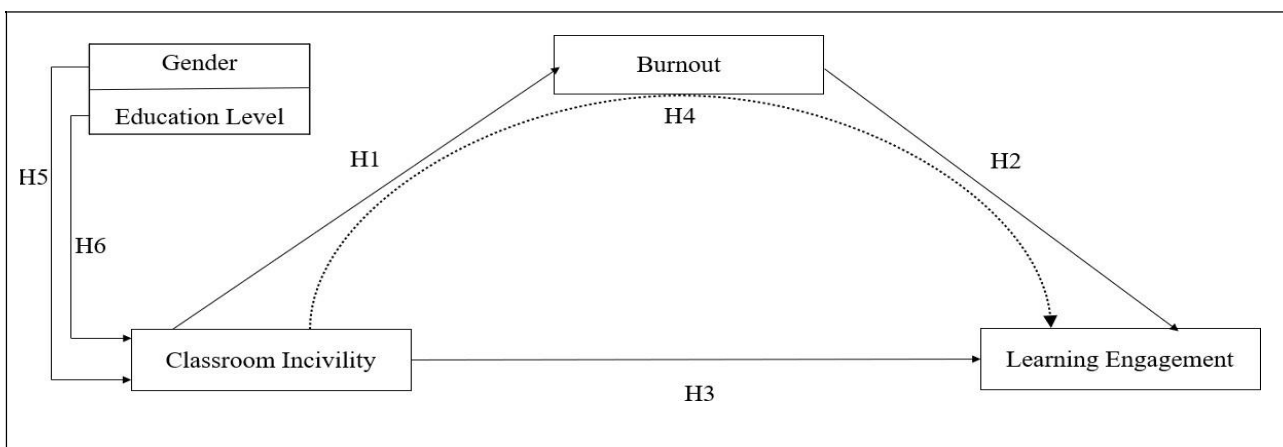
Objectives

1. To examine classroom incivility and student burnout relationship in select colleges of Chandigarh.
2. To examine burnout and learning engagement relationship of students in select colleges of Chandigarh.
3. To examine classroom incivility and learning engagement relationship of students in select colleges of Chandigarh.
4. To examine the role of burnout as mediator in classroom incivility and learning engagement relationship of students in select colleges of Chandigarh.
5. To examine significant difference between demographic variables and classroom incivility.

Hypotheses

1. Classroom incivility has a significant and positive impact on burnout of students in select colleges of Chandigarh.
2. Burnout has a significant and negative impact on learning engagement of students in select colleges of Chandigarh.
3. Classroom incivility has a significant and negative impact on learning engagement of students in select colleges of Chandigarh.
4. Burnout mediates classroom incivility and learning engagement relationship.
5. Gender (male & female) has significant difference in classroom incivility.
6. Education level (undergraduate and post graduate students) has significant difference in classroom incivility.

Figure 1. Conceptual Model



Source: Author's depiction based on literature review

Data Analysis and Results

The current study had a sample consisting of 298 students selected randomly from the colleges of Chandigarh. There were 178 males (60%) and 120 females (40%). The sample comprised 217(73%) students of undergraduate courses and 81(27%) students of postgraduate courses (see Table 2 and Table 3).

Table 2. Gender

Gender	Frequency	Percent
1	178	59.7
2	120	40.3

Source: Authors calculations based on primary data

Table 3. Education Level

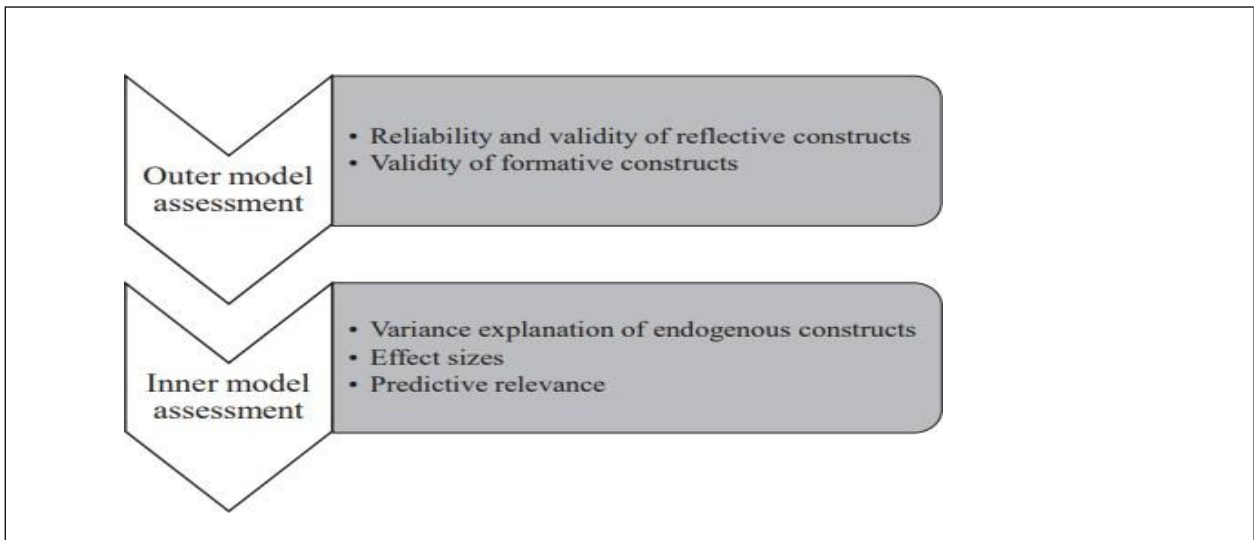
Education Level	Frequency	Percent
1	217	72.8
2	81	27.2

Source: Author's calculations based on primary data

Measurement Model

The hypothesized relationships are determined by the structural model. Validity and reliability are taken into account in the measurement model (Hair et al., 2019).

Figure 2. Method for Evaluating PLS Path Model

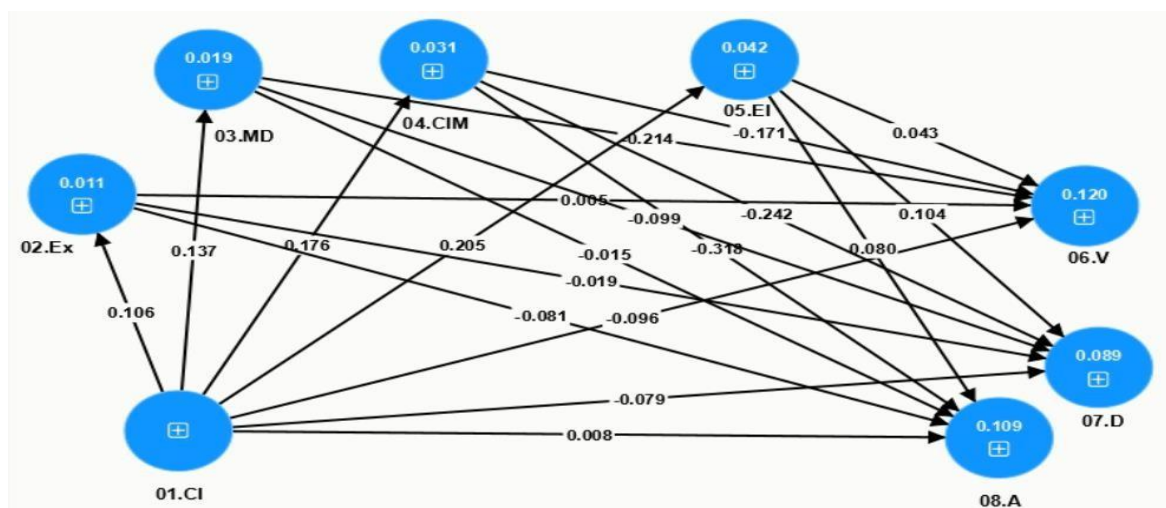


Source: A Two-Phase Method for Evaluating PLS Path Model Adapted from (Henseler et al., 2009)

Measurement Model (Lower-order Constructs)

Statistical software SmartPLS4 has been used to analyze data.

Figure. 3 Measurement Model



Source: PLS generated output

Note: CI=classroom incivility, Ex=exhaustion, MD= mental distancing, CIM= cognitive impairment, EI= emotional impairment V=vigor, D=dedication, A=absorption

The necessary 0.70 threshold has been attained by both Cronbach alpha and composite reliability, demonstrating their reliability.

Table 4. Factor Loading, Reliability and Validity Analysis

	Outer loadings	Cronbach's Alpha	Composite Reliability	Average Extracted (AVE)	Variance
CI1 <- 01.CI	0.69	0.93	0.94	0.57	
CI2 <- 01.CI	0.70				
CI3 <- 01.CI	0.77				
CI4 <- 01.CI	0.78				
CI5 <- 01.CI	0.77				

CI6 <- 01.CI	0.76			
CI7 <- 01.CI	0.70			
CI8 <- 01.CI	0.76			
CI9 <- 01.CI	0.79			
CI10 <- 01.CI	0.80			
CI11 <- 01.CI	0.76			
CI12 <- 01.CI	0.80			
B1 <- 02.Ex	0.93	0.77	0.82	0.61
B2 <- 02.Ex	0.57			
B3 <- 02.Ex	0.77			
B4 <- 03.MD	0.87	0.67	0.79	0.56
B5 <- 03.MD	0.83			
B6 <- 03.MD	0.48			
B7 <- 04.CIM	0.87	0.82	0.89	0.73
B8 <- 04.CIM	0.88			
B9 <- 04.CIM	0.82			
B10 <- 05.EI	0.82	0.78	0.87	0.69
B11 <- 05.EI	0.90			
B12 <- 05.EI	0.77			
V1 <- 06.V	0.66	0.82	0.86	0.51
V2 <- 06.V	0.68			
V3 <- 06.V	0.69			
V4 <- 06.V	0.63			
V5 <- 06.V	0.82			
V6 <- 06.V	0.80			
D2 <- 07.D	0.85	0.82	0.84	0.55
D3 <- 07.D	0.90			
D4 <- 07.D	0.87			
D5 <- 07.D	0.78			
A1 <- 08.A	0.76	0.85	0.88	0.55
A2 <- 08.A	0.64			
A3 <- 08.A	0.52			
A4 <- 08.A	0.86			
A5 <- 08.A	0.85			
A6 <- 08.A	0.79			

Source: Authors calculations based on primary data

Note: CI=classroom incivility, B=burnout, V=vigor, D=dedication, A=absorption

Construct Validity

Convergent and discriminant validity are the means by which construct validity is demonstrated. AVE statistics are the basis of the outcomes of convergent validity. It is proven, if the value of Average Variance Extracted (AVE) in comparison of suggested value of 0.50 is greater than or equal to (Fornell and Larcker, 1981).

Indicator Multicollinearity

Table 5. Multicollinearity Statistics (VIF) for Indicators

Items	VIF
A1	1.71
A2	1.59
A3	1.40
A4	2.19
A5	2.13
A6	1.94
B1	1.46
B2	1.66

B3	1.60
B4	1.28
B5	1.46
B6	1.27
B7	2.10
B8	2.28
B9	1.53
B10	1.75
B11	1.76
B12	1.48
CI1	2.24
CI2	2.15
CI3	2.15
CI4	2.33
CI5	2.24
CI6	2.10
CI7	1.95
CI8	2.32
CI9	2.35
CI10	2.51
CI11	2.39
CI12	2.49
D2	2.48
D3	3.07
D4	2.45
D5	1.86
V1	1.45
V2	1.66
V3	1.56
V4	1.51
V5	1.84
V6	1.58

Source: Authors calculations based on primary data

Note: A=absorption, B=burnout, CI=classroom incivility, D=dedication, V=vigor, VIF= Variance Inflation Factor

Discriminant Validity

AVE square root of given construct was higher as compare to other construct's correlation. Therefore, strong evidence were there for establishing discriminant validity (Fornell and Larcker, 1981) (see Table 6).

Table 6. Fornell-Larcker criterion

	01.CI	02.Ex	03.MD	04.CIM	05.EI	06.V	07.D	08.A
01.CI	0.76							
02.Ex	0.11	0.77						
03.MD	0.14	0.44	0.75					
04.CIM	0.18	0.41	0.55	0.86				
05.EI	0.21	0.49	0.36	0.49	0.83			
06.V	-0.15	-0.15	-0.30	-0.28	-0.13	0.72		
07.D	-0.12	-0.12	-0.21	-0.27	-0.07	0.70	0.85	
08.A	-0.04	-0.18	-0.20	-0.32	-0.12	0.66	0.69	0.75

Source: Authors calculations based on primary data

Table 7. Heterotrait-monotrait ratio (HTMT)-Matrix

	01.CI	02.Ex	03.MD	04.CIM	05.EI	06.V	07.D	08.A
01.CI								
02.Ex	0.15							
03.MD	0.18	0.60						
04.CIM	0.19	0.47	0.72					
05.EI	0.23	0.63	0.54	0.61				
06.V	0.16	0.15	0.31	0.31	0.16			
07.D	0.13	0.11	0.23	0.31	0.09	0.81		
08.A	0.09	0.15	0.21	0.33	0.12	0.76	0.77	

Source: Authors calculations based on primary data

Note: CI=classroom incivility, Ex=Exhaustion, MD= Mental distancing, CIM= Cognitive impairment, EI= Emotional impairment V=vigor, D=dedication, A=absorption

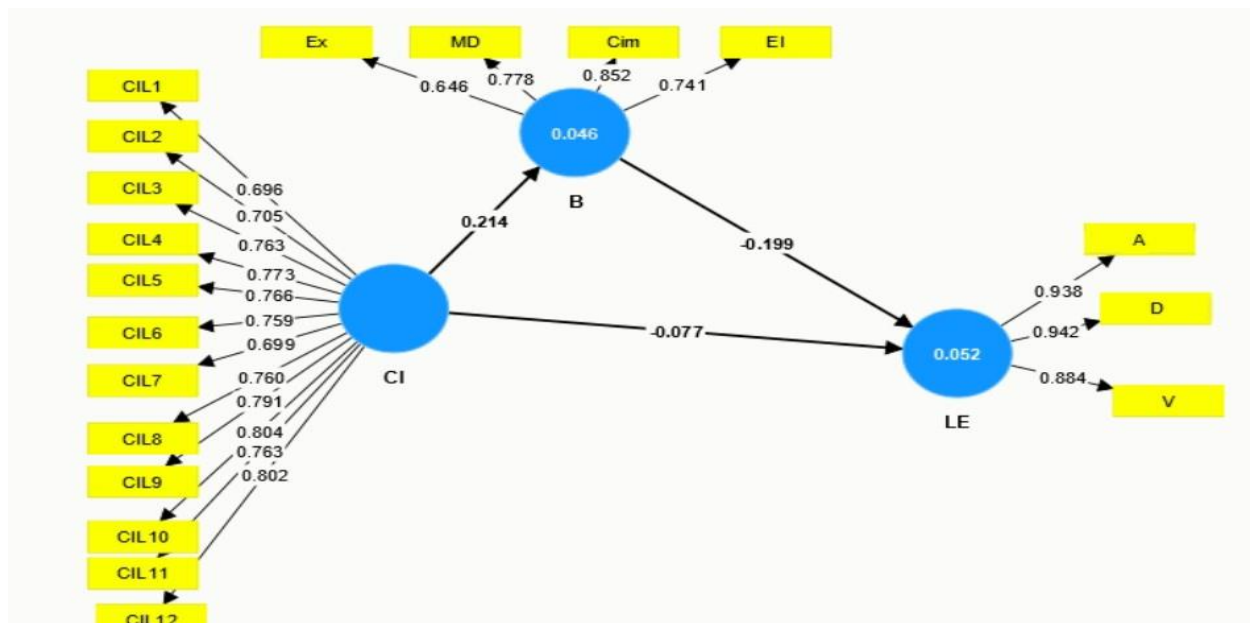
Table 8. Discriminant validity- Cross loadings

	01.CI	A	D	V	Ex	MD	CIM	EI
CI1	0.69	0.02	-0.07	-0.03	-0.03	0.05	0.06	0.11
CI2	0.70	-0.02	-0.10	-0.09	0.04	0.10	0.10	0.13
CI3	0.77	-0.01	-0.06	-0.07	0.19	0.16	0.17	0.22
CI4	0.78	-0.09	-0.10	-0.18	0.09	0.12	0.06	0.16
CI5	0.77	-0.04	-0.07	-0.12	0.07	0.11	0.17	0.16
CI6	0.76	-0.05	-0.11	-0.11	0.12	0.12	0.17	0.17
CI7	0.70	0.00	-0.04	-0.10	0.08	0.07	0.15	0.15
CI8	0.76	-0.04	-0.06	-0.09	0.07	0.08	0.05	0.15
CI9	0.79	-0.05	-0.06	-0.04	0.07	0.10	0.22	0.19
CI10	0.80	-0.03	-0.16	-0.18	0.06	0.07	0.16	0.11
CI11	0.76	-0.04	-0.08	-0.11	0.04	0.07	0.10	0.13
CI12	0.80	-0.01	-0.13	-0.17	0.06	0.14	0.12	0.15
A1	-0.05	0.76	0.47	0.48	-0.19	-0.14	-0.21	-0.02
A2	0.09	0.64	0.43	0.40	-0.07	-0.06	-0.11	0.00
A3	0.03	0.52	0.28	0.30	-0.02	-0.03	-0.06	-0.02
A4	-0.05	0.86	0.51	0.50	-0.18	-0.15	-0.29	-0.09
A5	-0.04	0.85	0.65	0.62	-0.12	-0.23	-0.35	-0.18
A6	-0.06	0.79	0.64	0.58	-0.13	-0.15	-0.23	-0.12
D2	-0.14	0.57	0.85	0.61	-0.09	-0.14	-0.18	-0.01
D3	-0.14	0.62	0.90	0.67	-0.13	-0.21	-0.25	-0.08
D4	-0.06	0.59	0.87	0.58	-0.10	-0.22	-0.26	-0.08
D5	-0.05	0.58	0.78	0.52	-0.07	-0.15	-0.20	-0.08
V1	-0.12	0.36	0.47	0.66	-0.11	-0.17	-0.11	-0.07
V2	-0.02	0.44	0.41	0.68	-0.03	-0.17	-0.08	-0.01
V3	-0.07	0.41	0.45	0.69	-0.07	-0.18	-0.16	-0.09
V4	0.02	0.54	0.48	0.63	-0.02	-0.10	-0.17	-0.09
V5	-0.14	0.52	0.56	0.82	-0.10	-0.29	-0.27	-0.11
V6	-0.18	0.58	0.60	0.80	-0.22	-0.28	-0.30	-0.16
B1	0.07	-0.18	-0.13	-0.16	0.93	0.38	0.37	0.43
B2	0.13	0.05	0.04	0.05	0.57	0.26	0.22	0.35

B3	0.13	-0.10	-0.05	-0.07	0.77	0.38	0.33	0.43
B4	0.08	-0.20	-0.22	-0.28	0.46	0.87	0.52	0.37
B5	0.16	-0.14	-0.16	-0.24	0.27	0.83	0.40	0.23
B6	0.10	0.02	0.04	-0.05	0.30	0.48	0.31	0.32
B7	0.21	-0.27	-0.21	-0.25	0.43	0.54	0.87	0.41
B8	0.10	-0.27	-0.22	-0.21	0.31	0.45	0.88	0.39
B9	0.14	-0.28	-0.26	-0.26	0.32	0.42	0.82	0.44
B10	0.15	-0.08	-0.06	-0.06	0.41	0.32	0.45	0.82
B11	0.21	-0.13	-0.08	-0.14	0.44	0.28	0.43	0.90
B12	0.13	-0.07	-0.04	-0.13	0.38	0.32	0.34	0.77

Source: Authors calculations based on primary data

Figure 4. Measurement model of Higher-order constructs



Source: PLS generated output

Note: CI=classroom incivility, B=burnout, LE=learning engagement

Table 9. Reliability and validity (Higher order construct)

	Cronbach's alpha	Composite Reliability	Average Variance Extracted (AVE)
LE	0.913	0.944	0.849

Source: Authors calculations based on primary data

Note: LE= learning engagement

Table 10. Fornell-Larcker criterion for validity

	B	CI	LE
B	0.758		
CI	0.214	0.758	
LE	-0.216	-0.12	0.921

Source: Authors calculations based on primary data

Note: CI=classroom incivility, B=burnout, LE=learning engagement

Table 11. Heterotrait-monotrait ratio (HTMT)-Matrix for higher order discriminant validity

	B	CI	LE
B			
CI	0.243		
LE	0.212	0.123	

Source: Authors calculations based on primary data

Note: CI=classroom incivility, B=burnout, LE=learning engagement

Table 12. Structural Model

	Beta	SD	t-value	P-values
H1 CI -> B	0.21	0.05	4.06	0.00
H2 B -> LE	-0.20	0.07	2.87	0.00
H3 CI -> LE	-0.08	0.07	1.16	0.25

Source: Authors calculations based on primary data

Note: CI=classroom incivility, B=burnout, LE=learning engagement

H1 evaluates whether burnout is impacted by CI significantly and positively. As per results CI has a significant and positive impact on burnout ($\beta=0.21$, $t=4.06$, $p<0.05$). Hence H1 was supported.

H2 investigates whether burnout has significant and negative impact on LE. The outcome displayed that burnout has a significant and negative impact on LE ($\beta=-0.20$, $t=2.87$, $p<0.05$). Hence H2 was supported.

H3 investigates whether CI has significant and negative impact on LE. The outcome displayed that CI has an insignificant and negative impact on LE ($\beta=-0.08$, $t=1.16$, $p>0.05$). Hence, H3 was not supported (see Table 12).

The SEM outcome displayed a strong positive correlation between burnout and CI. Burnout and LE are significantly correlated negatively. The correlation between CI and LE is negligible. Students will get more burned out and less engaged in studying if they encounter more incivility in the classroom.

Mediation Analysis

The mediation hypothesis (H4) was tested using the mediating procedure. The results depicted significant ($p>.05$) full mediation (see Table 13). The total effect of CI on LE was insignificant ($\beta=-0.120$, $t=1.897$, $p=0.058$). With the inclusion of mediator, the effect of CI on LE is significant ($\beta=-0.043$, $t=2.285$, $p<0.05$).

The direct effect was insignificant ($\beta=-0.077$, $t=1.156$, $p>0.05$). So, burnout fully mediates CI and LE relationship. Thus, H4 was supported.

Table 13. Mediation

Total Effect (CI -> LE)			Direct Effect (CI -> LE)				Indirect effect of CI on LE		
Coefficients	p-value	T-value	Coefficients	p-value	T-value		Coefficients	T-value	P-value
-0.120	0.058	1.897	-0.077	0.248	1.156	CI -> B -> LE	-0.043	2.285	0.022

Source: Authors calculations based on primary data

Note: CI=classroom incivility, LE=learning engagement

H5. Gender (male & female) has significant difference in classroom incivility.

For gender-based comparison of CI; an independent sample t-test was run. There were no observable variations ($t(df)=296$, $p=0.889$) in female scores ($M=0.85$, $SD=0.92$) and male scores ($M=0.86$, $SD=0.92$) (see Table 14). The results of mean difference were insignificant ($MD=0.014$, 95%, CI: -0.19 to 0.28). **Hence, H5 was not supported.**

Table 14. Classroom incivility between male and female students

		Levene's Test				t-test for Equality of Means				
		Mean	SD	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
CI	Male	.86	.88	.38	.53	.14	296	0.17	-0.23	0.17
	Female	.85	.92			.13				

Source: Authors calculations based on primary data

Note: CI=classroom incivility

H6. Education level (undergraduate and post graduate students) has significant difference in classroom incivility.

The comparison of CI based on education level; an independent sample t-test was performed. No observable differences were found ($t(df) = 296, p = 0.61$) in scores for UG ($M = 0.76, SD = 0.87$) and PG ($M = 1.12, SD = 0.92$). Mean difference results were insignificant ($MD = 0.36, 95\% CI: -0.19$ to 0.28) (see Table 15). **Hence H6 was not supported.**

Table 15. Classroom incivility between UG and PG students

		Levene's Test				t-test for Equality of Means				
		Mean	SD	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
CI	UG	.76	.87	.25	0.61	3.19	296	0.002	0.36	0.11
	PG	1.12	.92			3.10				

Source: Authors calculations based on primary data

Note: CI=classroom incivility, UG= undergraduate, PG= post graduate

Conclusion and Recommendations

The current study's main objective was to look into the connections both direct and indirect between LE and CI. Burnout's role in indirect relationships has been investigated. It is determined that there was full mediation of burnout between the LE and CI relationship. It has been shown that CI has an impact on burnout rather than having a direct impact on learning engagement (0.21). This supports the findings of earlier research (Hong et al., 2016; Taylor et al., 2017; Shi et al., 2018). Classroom incivility has a direct impact on student well-being, as rising levels of disrespect and disruptive behavior significantly contribute to increased burnout among students. Research has shown that burnout has a profound negative effect on learning engagement (-0.20) supporting findings from previous study (Uludağ and Yaratana, 2010). This evidence highlights the urgent need to address burnout in order to enhance educational outcomes. Studies have also looked at the significant differences in CI based on gender and education level. It was discovered, there was no significant difference in classroom incivility based on male or female students. These results do not support the findings of previous studies (Boice 1996; Arbuckle & Little, 2004). Furthermore, there is no evident variation in the level of incivility in the classroom based on education level (undergraduate and post graduate) of students.

Reducing classroom incivility and enhancing learning engagement while addressing burnout requires a multifaceted approach that promotes a respectful, inclusive, and supportive environment. First, it is essential to establish clear expectations for behavior by setting ground rules that emphasize respect and collaboration, while also holding students accountable for their actions. Creating a positive classroom culture involves fostering open communication, modeling civility, and ensuring that all students feel valued and heard. Engaging students actively through interactive learning strategies, such as group work, discussions, and problem-solving activities, helps keep them invested in the material. Thoughtful incorporation of technology can also make classes more dynamic, but it is important to set boundaries to minimize distractions.

Addressing student well-being is crucial. Teachers should be mindful of signs of burnout, offer support, and encourage self-care to help students balance academic demands with personal needs. Providing timely and constructive feedback that focuses on growth, along with recognizing effort, helps maintain motivation. Additionally, developing meaningful relationships with students fosters a sense of belonging and investment in the learning process. Offering flexible learning options, such as varied assessments, can accommodate different learning styles and reduce stress. Continuously reflecting on teaching practices and seeking student input allows instructors to improve their approaches and make necessary adjustments. Finally, addressing conflicts promptly and teaching students conflict resolution skills can reduce instances of incivility, ensuring a harmonious classroom environment. By implementing these strategies, educators can foster a culture of respect, reduce burnout, and enhance overall student engagement and success.

Implications of the Study

The theoretical knowledge on classroom incivility is expanded by this study. The available literature is on workplace incivility. In Indian context, there are no studies on classroom incivility. The papers cited in this study are all done in Western countries. In India, it's a need of an hour to deal with such uncivil behavior of students. Being rude to others causes weariness, mental detachment, cognitive decline, and emotional decline. And ultimately it is going to impact learning engagement of students. Through this side it is identified that incivility leads to burnout and then impacts learning engagement.

One can be directly or indirectly impacted by rude behavior. There are worse outcomes when such behavior goes unnoticed and without corrective action being done. This study draws attention to classroom rudeness for the benefit of students' wellbeing. Whether deliberate or inadvertent, incivility can have negative consequences. Although incivility can occur accidentally or on purpose, this study will force educational institutions to address these behaviors early on to prevent them from developing into more serious issues.

In the classroom, disrespect impedes students' intellectual and academic growth and lessens their motivation to use critical thinking skills throughout class. Their impolite behavior in class cause interruptions to the learning environment and causing distractions for other students. Peer support will be decreased by classroom incivility, and this will have a detrimental effect on family life, on sound sleep, mental health, and emotional well-being.

The findings also showed us that in order to minimize these issues and preserve a positive learning environment, we must deal with classroom incivility and burnout.

Limitations and Future Research Directions

One significant limitation of this study is its primary reliance on quantitative research methods. This approach tends to narrow the scope of analysis, missing out on valuable subjective insights and more nuanced perspectives that could have been captured through a blend of both qualitative and quantitative methods, ultimately enriching the findings.

Another limitation is sample size. A total of 400 participants were initially contacted, and 320 responded. Out of these, 298 were thoroughly analyzed after eliminating outliers and resolving missing values, ensuring the integrity of the findings.

Based on the findings and limitations of this investigation, future directions are suggested for further research in the same area. The current study was conducted at a single point in time, so a longitudinal study over several months or years is recommended to obtain more comprehensive results. In future research, employing interview or observation methods could help identify a range of perspectives on classroom incivility, burnout and learning engagement.

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Growing Opportunities: Unpacking the Horticulture Growth Trend in Manipur

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Abstract

Given the increasing demand for food grains and other crops, an important aim of economic growth and development is to achieve self-sufficiency in agricultural production. Manipur, a small hilly state in north-eastern India, is a storehouse of many Indigenous and underutilized horticulture crops that are valuable in bioactive components and are used in ethnomedicine. Fruits, spices, and vegetables have high demand in the market and are rich sources of vitamins. The study analyzes the trend in agricultural land use and the production within horticulture, including fruits, vegetables, and spices. The study investigates using panel data analysis with secondary time series data from 2012-2022. Techniques like regression, fixed effects model, random effects model, and the Hausman test are applied. In the study, it was shown a consistent pattern among agricultural land and its usage over time, but the production of fruits and vegetables underwent radical changes. The regression models reveal a decrease in land area for growing fruits by 138 units yearly. However, concerning the vegetable area, the regression analysis results indicate that the area increases at about 186 units per year, though the significance level is low ($p = 0.082$). The fixed effects model and random effects model show a positive increase of about 186 units annually. For spice, there has been no statistically significant effect on the spice areas through years. The Hausman test believes that the random effects models best fit this type of data analysis, which calls for considering the unobserved variables that are affecting land use. However, the trend in results from the R-square value and high standard errors indicates that various important factors are excluded. The study suggests a need for a greater emphasis on a multifactor approach, which would combine climatic, socio-economic, and geographical features. The paper calls for incorporating additional factors that may help better understand the influence on agricultural patterns in the long run.

Keywords: Horticulture growth, Agriculture Land use, Production trends, Manipur.

Introduction

Horticulture, which is also referred to as the branch of agriculture, is one of the most profitable sectors in the country's economy. India is diverse in agro-climatic and has a rich biodiversity, which is suitable for growing various horticultural crops. India has achieved its second highest position in the production of vegetables and fruits globally. It takes the lead in varieties of horticultural crops such as papaya, banana, and mango (Dar, 2017). The region of northeast India has 50 percent of the country's biodiversity and 7.7 percent of the overall land area of the country. This region is famous for its diverse natural topography, soil, and climate, which results in the cultivation of diverse fruits, vegetables, medicinal plants, flowers, and spices (Deka et al., 2012). The importance of horticulture cannot be overemphasized as it is significant in increasing land productivity, creating jobs, raising the economic status of farmers and entrepreneurs, boosting the export market, and, most importantly, ensuring the nutritional needs of the inhabitants of the desert (Bhandari et al., 2014).

The percentage of vegetable output to the total vegetable and fruit production in Manipur, a small hilly state in north-eastern India, improved from approximately 26% in 2005-06 to roughly 40% in 2015-16. However, the percentage is much lower than the national share of 64%, consistent throughout the period. Vegetables spanned an area of 34,160 ha, producing an average of 315 thousand metric tonnes each year, representing 0.34% and 0.19% of the national totals. The production of vegetables in the state is 9.22 metric tonnes, much below the 16.73 metric tonnes per hectare national average on a per-hectare basis. Nonetheless, the rising patterns in area and output observed since 2000-01 indicate significant potential for Manipur's fruits and vegetable industry (Devi, 2019).

Manipur is a storehouse of many Indigenous and underutilized horticulture crops that are valuable in bioactive components and are used in ethnomedicine. Despite its potential, the sector remains commercially unexploited. In 2014-15, the area cultivated with horticultural crops was 100.01 thousand hectares, yielding a production value of 1,159.03 thousand tonnes (Roy et al., 2018). Manipur is conducive to the development of the fruit and vegetable industry owing to its various agricultural and climatic conditions. The state has significant potential in the development of fruits and vegetables. Nevertheless, owing to insufficient irrigation infrastructure, the agriculture of the state is significantly reliant on the unpredictability of the rainy season and frequently exposed

to erratic climate circumstances, leading to substantial variations in output levels. Horticultural crops such as vegetables do not need perpetual watering. These are short-duration crops that generate more output per unit area compared to cereal crops such as rice, hence providing enhanced benefits to smallholder and small-scale farmers in Manipur engaged in vegetable farming. Furthermore, it serves as a significant source of employment owing to its labour-intensive nature. The output from this domain may serve as a stimulus for development by supplying unprocessed materials to emerging small-scale regional agrobusinesses in the state. This field has emerged as the most important and dynamic element of the state's agriculture industry. The changing horticulture scenario in Manipur indicates that there is a need for research and policy support so that the resources available can be optimally exploited and thereby assist in the region's overall economic growth.

Therefore, this paper adds to the growing literature and aims to assess the performance related to the area and output of fruits, vegetables, and spices in the horticulture sector of Manipur. In addition, this paper also makes a comprehensive study of the significance of area and production in the growth of horticultural crops. Our study answers the following research questions:

What is the trend in the area allocation of horticulture cultivation in Manipur, mainly fruits, vegetables, and spices?

How has Manipur's horticulture output (fruits, vegetables & spices) changed?

Are there significant differences in the performance of horticulture crops, i.e., fruits, vegetables, and spices, in terms of their area and output?

What is the significance of area and production in the growth of horticultural crops in Manipur?

Review of Literature

Kamei (2013) provided an overview of the function of horticulture in historical contexts and international, national, regional, and state challenges, focusing on the Tamenglong district. An in-depth review is carried out in hilly and mountainous regions and the rural developmental challenges associated with it. Numerous academicians, scientists, governments, and NGOs have recognized the significance of horticulture and its related fields.

In the districts of Manipur and Bishnupur, Devi (2019) established positive growth rates for the area and yield of certain vegetables grown in the area. The study provides valuable insight into the growth trend of vegetables over a decade. Cabbage was the largest vegetable crop growing in the state of Manipur. The increase in vegetables was mainly because of area expansion rather than the improvement in productivity. The study brings out the significance of the area in planting vegetables. The study provides valuable insight into the growth trend of vegetables over a decade.

Singh and Bera (2017) showed that net cropping, cropped area, and planting rose between the years 1987 and 2012-13 but showed a decline in irrigated areas. The share of fruits, vegetables, and spices has risen to 14.78% per hectare. All main crops have positive growth rates but are subject to medium to high uncertainty. For food grains and vegetables, the area effect leads to increased output expansion, while productivity expansion has high contributions to greater yields for fruits and spices.

According to Zou and Muan (2020), the varied agro-climatic circumstances in India and agricultural products are significant drivers of the country's finances, making it ideal for agro-based industries. Rapid industrialisation and literacy growth have created new market opportunities. Indians spend almost half of their household budget on food items, which makes the agro-based food manufacturing sectors attractive to young entrepreneurs and farm workers.

Biswas et al. (2020) study found that some of the cultivated areas in Manipur, which is not more than 10% of the total area available, need to increase so that food requirements are met. This paper, covering the period 1997 to 2016, is covered by the authors with respect to ten different crops comprising grains, corn, oilseeds, legumes, fruits, vegetables, pineapple, citrus, ginger, and turmeric crops. The trends determined for the rice yield, total oilseeds, and turmeric are cubic polynomials; corn has quadratic trends; the trends for total pulses are linear; and the trends for chili and veggies are complex.

Kumar (2022) in his study, reveals that the consumption of fruits and vegetables increased in rural areas by 18-23% and 10-20%, respectively, between 1993-94 and 2011-12. He mentioned challenges regarding low productivity growth, export limitation, and poor value realization. The study suggests the need to improve productivity growth, diversify export destinations, and encourage value addition and entrepreneurship in processing to improve the performance of India's horticulture sector.

Study by Gupta (2022) reveals that there is a rise in the growth of production for fruits and vegetables with low instability and moderate instability for spices. It indicates that fruits can be cultivated in Meghalaya, Manipur, and Assam, which have low instability indices. The study mentioned that horticulture has the prospects of enhancing the north-east economy significantly.

Research Gap

Research in many aspects regarding Manipur's agricultural and horticultural development has been pursued, but there are gaps to fill. Different studies have focused on specific crops like vegetables or staple crops. On the other hand, the overall group of fruits, vegetables, and spices has attracted little research attention, with a specific focus on the differences in growth and productivity throughout the years. In addition, although the area is considered a significant factor influencing production development, productivity, and yield, especially with respect to fruits and spices, it receives inadequate attention. There is a lacuna in understanding the factors that have shaped Manipur's unexplored horticultural development until now and the specific requirements that need to be fulfilled to ensure continued agricultural development in various regions of Manipur.

Objective of the study

The main objective of the study is to analyse the trend in agricultural land use and the production within horticulture, including fruits, vegetables, and spices. Therefore, the following are the specific objective of the study:

1. To assess the performance related to the area and output of fruits, vegetables, and spices in the horticulture sector of Manipur.
2. To comprehensively study the significance of area and production in the growth of horticultural crops.

Methodology

The study was conducted for Manipur to track the growth of horticulture by using panel data regression analysis using different techniques such as Fixed effects Model (FEM), Random Effects Model (REM) (Hung et al., 2023; Zhai & Guyatt, 2024), focusing on secondary time series data on fruits, vegetables, and spices. The study was conducted using the Stata tool, enabling it to assess the trends in agricultural land use and production throughout Manipur. This approach allows us to observe the change in horticulture growth over the years. The steps in methodology include:

Data collection

The data for this research were obtained from secondary sources provided by the Department of Horticulture and Soil Conservation, Government of Manipur. The study covered a period of ten years, from 2012-13 to 2021-22. The study primarily aims to collect data on multiple years of agricultural records, such as cultivated area and production of fruits, vegetables, and spices. This study is limited to secondary data due to its reliability, feasibility, and comprehensiveness.

Model Specification: Constructing a regression model where the year serves as the independent variable and the areas dedicated to fruits, vegetables, and spices are treated as dependent variables.

Model Estimation: To estimate the regression model using Fixed Effects Model (FEM) and Random Effects Model (REM).

Model Selection: Hausman test is aimed at assessing which of the Fixed Effects Model or the Random Effects Model is suitable for assessing the data.

Hypothesis Testing: Testing the hypothesis that year and area have a significant impact on agricultural development and production by evaluating the p-values and confidence intervals associated with the regression coefficients.

Robustness Checks: Carrying out further tests to verify the reliability of the results, which involves evaluating multicollinearity, heteroskedasticity, and autocorrelation.

Scope of the study: The scope of the present study is limited to the horticulture sector of Manipur, which focuses specifically on fruits, vegetables, and spices from 2012-2013 to 2021-2022.

Results & Discussion:

Fruits:

Table 1 Regression

Fruits Area	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
YEAR	-138.0458	88.47978	-1.56	0.122	-313.881	37.78918
_cons	283816.5	178419.7	1.59	0.115	-70755.1	638388.1

Table 1. Using Stata, regression analysis was done to examine the connection between YEAR (the independent variable) and Fruits Area (the dependent variable). The negative coefficient YEAR indicates that the fruit area under cultivation is decreasing by about 138 units. The commonly accepted significance criterion is 0.05, although YEAR's p-value of 0.122 is higher, indicating that this trend is not statistically significant. The lack of solid proof against the null theory that YEAR does not affect the fruit area is suggested. For YEAR, the 95% confidence interval is from -313.88 to 37.79. Although the constant (_cons) is 283,816.5, it is not statistically significant (p = 0.115). Regarding these numbers, the model doesn't prove beyond a reasonable doubt that YEAR has a big effect on the fruit area.

Table 2 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.2067		min =10				
between = .		avg =10				
overall = 0.0269		max =10				
corr(u_i, Xb) = -0.0000		F(1,80) =20.85				
		Prob > F =0				
Fruits Area	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
Year	-138.0458	30.23385	-4.57	0	-198.213	-77.8785
_cons	283816.5	60966.63	4.66	0	162489	405144

Table 2. Based on the fixed-effect (within) regression model, it has 90 observations spread out over 9 groups, with an average of 10 observations in each group. This means the independent variable (Year) can explain about 20.67% of the difference in the dependent variable (Fruits Area) within the groups. The within-group R-squared number is 0.2067. The total R-squared value of 0.0269 and the between-group R-squared numbers are not helpful in this case. The model seems to be very important, with an F-statistic of 20.85 and a p-value of 0.000. The value for the variable "Year" is -138.0458, which means that if all other factors stay the same, the area used for growing fruit declines by an average of 138.05 units per year as time goes on. The 95% confidence range for this result is between -198.213 and -77.8785, which means it is statistically significant negative effect of "Year" on "Fruits Area" (p < 0.05). The value of the constant term (_cons) is 283,816.5, which is the average amount of the Fruits Area when the Year variable is set to 0. This model shows that the Fruits Area has been going down over time.

Table 3 Random Effect Model

Random-effects GLS regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0000		min =10				
between = 0.0000		avg =10				
overall = 0.0269		max =10				
corr(u_i, X) = 0 (assumed)		Wald chi2(1) =20.85				
		Prob > chi2 =0				
Fruits Area	Coef.	Std. Err.	z	P>z	[95%Conf.Interval]	
Year	-138.046	30.23385	-4.57	0	-197.303	-78.7885
_cons	283816.5	60971.78	4.65	0	164314	403319

Table 3. The results of the R-squared numbers demonstrate that the model fails to account for any variation within or across groups (R-squared values: 0.0000 for both the within and between groups). The model accounts for 2.69 per cent of the total variance in the dependent variable, indicated by an R-squared value of 0.0269. The model fits the data correctly because the Wald chi-squared measure is significant ($\chi^2 = 20.85$, $p < 0.001$). "Year" has a value of -138.046, which is of statistical significance ($p < 0.001$). In other words, the relationship between the year and the area of crops is inversely related., with a 95% confidence range of -197.303 to -78.7885. Also, the constant term (_cons) is important ($p < 0.001$); it has a value of 283816.5 and shows the expected fruit area when all other factors stay the same.

Hausman test:

Table 4 Hausman Test

Dependent variable	p-value	Chi-square test	Test of summary
Fruits Area	>0.05	>0.05	Random effect

Table 4. Because the p-value exceeds 0.05, it indicates that the random effects model is more appropriate for the data, enabling the acceptance of the null hypothesis. This analysis shows that the individual-specific effects do not correlate with the regressors, suggesting that we should opt for the random effects model.

Table 5 Regression

Fruits Production	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
year	53.62686	858.1559	0.06	0.95	-1651.78	1759.031
_cons	-54791.19	1730473	-0.03	0.975	-3493743	3384161

Table 5. The regression analysis aimed to determine how output fruit is related to the variable year. Since the finding is statistically unimportant ($P > 0.95$), the estimate for the year variable is 53.63, which suggests that fruit production has gone up over time, but not by much. There is much variation around the number, as shown by the big standard error (858.16). The confidence range is also very large (-1651.78 to 1759.03), which shows that the number is not certain. The constant (_cons) is -54791.19, and the standard error is even bigger. This means that there is no meaningful relationship ($P > 0.975$). The study shows that the year does not greatly affect this model's ability to predict fruit production.

Table 6 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0003		min =10				
between = .		avg =10				
overall = 0.0000		max =10				
corr(u_i, Xb) = 0.0000		F(1,80) =0.02				
		Prob > F =0.8811				
Fruits Production	Coef.	Std. Err.	t	P>t	[95% Conf.Interval]	
Years	53.62686	357.4098	0.15	0.881	-657.641	764.8951
_cons	-54791.19	720717.7	-0.08	0.94	-1489065	1379483

Table 6. The fixed-effects regression model was calculated using 90 observations spread across 9 groups, with 10 observations on average per group. Very little information was explained by the model (0.0003) about the changes in fruit production within groups over time. Additionally, the total R-squared was very small (0.0000), demonstrating that the model struggled to provide clear explanations. According to the model, the F-statistic was 0.02, and the p-value was 0.8811. This indicates that the predictor variable (Years) does not significantly explain the difference in fruit production. Although the "Years" coefficient was 53.63, the finding was not statistically significant ($p = 0.881$), and the 95% confidence interval was very large, spanning from -657.64 to 764.90. Furthermore, the fixed term (_cons) was not important. According to the results, "Years" is not a good indicator of fruit output in this fixed-effects model.

Table 7 Random Effect Model

Random-effects GLS regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0000		min =10				
between = 0.0000		avg =10				
overall = 0.0000		max =10				
corr(u_i, X) = 0 (assumed)		Wald chi2(1) =0.02				
		Prob > chi2 =0.8807				
Fruits Production	Coef.	Std. Err.	z	P>z	[95% Conf.Interval]	
year	53.62686	357.4098	0.15	0.881	-646.884	754.1373
_cons	-54791.19	720756	-0.08	0.939	-1467447	1357865

Table 7. The GLS regression model with random impacts was run on 90 observations spread out over 9 groups, with an average of 10 observations in each group. The outcomes reveal that the model fails to provide any explanation in the domains of within, between, and overall effects since all three R-squared values are 0.0000. The Wald chi-squared statistic is 0.02, with a corresponding p-value of 0.8807. This indicates that the model is not statistically significant. Since the p-value for this variable is 0.881 and the coefficient for the variable "year" is 53.63, we can conclude that the effect of the year on fruit production is not statistically significant. The parameter as a constant (_cons) and a standard error of -54791.19 is very high. This is another sign that the model is not very accurate or meaningful. Ultimately, it was decided that the model does not explain any major changes in fruit output over time.

Hausman test:

Table 8 Hausman Test

Dependent variable	p-value	Chi-square test	Test of summary
Fruits Production	>0.05	>0.05	Random effect

Table 8. A p-value in excess of significance level 0.05 concludes that the random effects model is more appropriate and affirms the null hypothesis. Consequently, it implies that no strong proof exists to show any link between random effects and the explanatory variables. It is clear that the random effects model is a more appropriate fit for the data.

Vegetables:

Table 9 Regression

Vegetables Area	Coef.	Std. Err.	T	P>T	[95% Conf.	Interval]
Year	186.0237	105.5806	1.76	0.082	-23.7956	395.8429
_Cons	-371251	212903.5	-1.74	0.085	-794352	51850.18

Table 9. Regression analysis was used to examine how the year and the area of vegetables were related. A Year has a value of 186.0237 and 105.5806 as the standard error. This indicates the link between the two, which means that the area of veggies grows by about 186 units for every extra year. Concurrently, however, with a p-value of 0.082, we surpass the generally acknowledged 0.05 threshold for significance. Statistical significance is almost at hand at the 10% level, but it is not evident at the 5% level. The constant's (_Cons) standard error is 212,903.5 and its coefficient is -371,251, indicating a negative intercept. The intercept is not statistically significant (p=0.085), with a significance level of 5%. There is a 95% CI for Year, and the constant shows a range of possible values, but they both include zero, which shows that this model does not have much statistical significance. Generally, there is a solid association between the year and the vegetable area, but the outcomes are unimportant.

Table 10 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0790		min =10				
between = .		avg =10				
overall = 0.0341		max =10				
corr(u_i, Xb) = 0.0000		F(1,80) =6.86				
		Prob > F =0.0106				
Vegetables Area	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
year	186.0237	71.03294	2.62	0.011	44.66361	327.3837
_cons	-371251	143238.1	-2.59	0.011	-656304	-86198

Table 10. The results of the Fixed Effect regression model are presented, with the dependent variables as Vegetables area. Analysis has revealed that the R-squared value is 0.0790, meaning the independent variable (year) explains about 7.9% of the variance observed in the dependent variable. The model's F-statistic, which was also found to be strong, had a value of 6.86 with 0.0106 as its p-value. The variable "year" coefficient is 186.0237, and the standard error is 71.03294. The t-value= 2.62 and p-value= 0.011 provide evidence of a strong relationship between these two variables. Holding other factors constant, there is an annual increase of roughly 186.02 in the area designated for vegetables. On the other hand, the constant term (_cons) is -371,251, which is also statistically significant (p = 0.011). The fixed effect model outlines the strong and favorable connection between the two variables "year" and "vegetable areas," indicating that the areas for vegetables have increased.

Table 11 Random Effect Model

Random-effects GLS regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0000		min =10				
between = 0.0000		avg =10				
overall = 0.0341		max =10				
corr(u_i, X) = 0 (assumed)		Wald chi2(1) =6.86				
		Prob > chi2 =0.0088				
Vegetables Area	Coef.	Std. Err.	z	P>z	[95% Conf.Interval]	
year	186.0237	71.03294	2.62	0.009	46.80166	325.2457
_cons	-371250.8	143240	-2.59	0.01	-651996	-90505.6

Table 11. The effects of probability GLS regression study of a dataset with 90 observations spread across 9 groups revealed important information about how the variable "year" affected the result related to vegetables. The model shows a statistically significant positive coefficient for "year" (Coef. = 186.02, p = 0.009). This means that the result related to vegetables goes up by about 186.02 units for every extra year, with a 95% confidence interval spanning from 46.80 to 325.25. It is also that the intercept term (_cons) has a statistically significant value of -371250.8 (p = 0.01), which means it has a baseline effect. The Wald chi-squared test measure (chi2(1) = 6.86, p = 0.0088) denotes on the whole, the model is generally significant, but the R-squared values show that it does not explain much within or between groups (within = 0.0000, between = 0.0000). So, even though the model shows results that are statistically significant, the low R squared values suggest that other factors may need to be looked at in order to better understand the differences in the results for vegetables.

Hausman test:

Table 12 Hausman Test

Dependent variable	p-value	Chi-square test	Test of summary
Vegetables Area	>0.05	>0.05	Random effect

Table 12. The results of the Hausman test suggest that the Random Effects model is appropriate for the data because there is no correlation observed between the random error term and the independent variables. A p-value in excess of significance level 0.05 concludes that the random effects model is more appropriate and affirms the null hypothesis.

Table 13 Regression

Vegetable production	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
year	1886.023	723.6077	2.61	0.011	448.0051	3324.042
_cons	-3767163	1459156	-2.58	0.011	-6666929	-867396

Table 13. A regression study of vegetable production shows that the variable "year" has a strong positive relationship with vegetable output, as shown by a coefficient of 1886.023. This means that vegetable output increases by 1886 units for every additional year. The p-value of 0.011 shows statistical significance. The standard error for this number is 723.6077, which shows good accuracy. This coefficient shows that the 95% confidence interval ranges between 448.0051 and 3324.042 shows the reliability of the estimate. If all the variables are zero, conversely, the intercept (_cons) is negative at -3767163 with a p-value of just 0.01. It proves that the starting point is of statistical significance. In general, the data show that vegetable production has increased over the years, which shows how time may affect farming outputs.

Table 14 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.3573		min =10				
between = .		avg =10				
overall = 0.0717		max =10				
corr(u_i, Xb) = -0.0000		F(1,80) =44.48				
		Prob > F =0				
Vegetable production	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
year	1886.023	282.7834	6.67	0	1323.267	2448.78
_cons	-3767163	570233.3	-6.61	0	-4901963	-2632362

Table 14. Vegetable production has a strong positive link with the variable "year," as shown by the coefficient of 1886.023. With a statistical significance p-value of 0.011. This indicates that annual vegetable output increases by around 1,886 units. We can see that this coefficient has a good level of accuracy because its standard error is 723.6077. The estimate is more likely to be correct since, for this coefficient, the 95% CI falls somewhere in the middle. 448.0051 and 3324.042. The intercept (_cons), on the other hand, is negative at -3767163, together with a p-value of just 0.011. The baseline value is, therefore, significantly different from zero when all indicators are zero. Overall, the data show that veggie production has increased over the years, which shows how time may affect farming outputs.

Table 15 Random Effect Model

Random-effects GLS regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0000		min =10				
between = 0.0000		avg =10				
overall = 0.0717		max =10				
corr(u_i, X) = 0 (assumed)		Wald chi2(1) =44.48				
		Prob > chi2 =0				
Vegetable Production	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Year	1886.023	282.7834	6.67	0	1331.778	2440.269
_Cons	-3767163	570268.6	-6.61	0	-4884869	-2649457

Table 15. The random-effects generalized least squares (GLS) regression analysis was done on 90 values spread out over 9 groups. The goal of the model was to look at how the variable "Year" affected the growth of vegetables. The model has very little power to explain things because both the within-group and between-group R-squared values are 0.0000, and the total 0.0717 is the R-squared value. For vegetables, this proves that the framework does not explain the vast majority of yield fluctuations. The variable "Year" has a value of 1886.023, which means that it possesses a statistically significant positive relationship with vegetable production ($z = 6.67$, $p < 0.001$). The constant term (_Cons), on the other hand, is -3767163, a very significant negative number in statistics. finding ($z = -6.61$, $p < 0.001$). This means that the average vegetable production is much lower when the offset is considered. This is because the model may not have considered everything that may have impacted the output. The results show how important time is for figuring out how vegetable production changes over time, even though the model does not fit perfectly.

Hausman test:

Table 16 Hausman Test

Dependent variable	p-value	Chi-square test	Test of summary
Vegetable Area	>0.05	>0.05	Random effect

As the p-value is greater than 0.05, it is possible to accept the null hypothesis when using the random effects model. Since the individual effects are not correlated with the regressors.

Spices:

Table 17 Regression

SpicesArea	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
year	11.17542	64.22764	0.17	0.862	-116.464	138.8144
_cons	-21096.8	129515.2	-0.16	0.871	-278481	236287.4

Table 17. The Spice area's regression analysis shows a standard error of 64.228 and a coefficient of 11.175 for the "year" variable. According to the findings, the year hardly influences the t-value (0.17) and p-value (0.862). spices area at the conventional level. There is a 95% chance that the year is between -116.464 and 138.814, which is a large range with little strong evidence of an effect. The constant has a -21096.8 as the coefficient and 129515.2 as the standard error; these statistical values are $t = -0.16$, $p = 0.871$, and a confidence range from -278481 to 236287.4. The results indicate that neither the "year" nor the intercept are significant predictors of the "spice area."

Table 18 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90				
Group variable: id		Number of groups =9				
R-sq:		Obs per group:				
within = 0.0005		min =10				
between = .		avg =10				
overall = 0.0003		max =10				
corr(u_i, Xb) = 0.0000		F(1,80) =0.04				
		Prob > F =0.8469				
Spices Area	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
year	11.17542	57.69311	0.19	0.847	-103.638	125.9884
_cons	-21096.8	116338.3	-0.18	0.857	-252617	210423.8

Table 18. A dataset of 90 observations, divided into 9 groups of 10, was subjected to the fixed-effects (inside) regression model. The R-squared values reveal a poor match (0.0005 for within-group and 0.0003 for outside-group) and no mention of the between-group. With a value of 0.0000 for Corr (unit, Xu), we may conclude that the explanatory variables do not contribute to the group effects. A p-value of 0.8469 and an F-statistic of 0.04 for the model suggest that there is no statistical significance. A margin of error of 57.69311 is linked with the dependent variable "year" and its coefficient is 11.17542. This has given a t-value of 0.19 and a p-value of

0.847, is a statistically significant impact. The constant term has a standard error of 116338.3 and a co-efficient of -21096.8. Its p-value of 0.857 suggests the intercept is not significant. The 95% confidence ranges for the year, and constant terms are very large and include zero, proving that there is no statistical significance.

Table 19 Random Effect Model

Random-effects GLS regression			Number of obs =90			
Group variable: id			Number of groups =9			
R-sq:			Obs per group:			
within = 0.0000			min =10			
between = 0.0000			avg =10			
overall = 0.0003			max =10			
corr(u_i, X) = 0 (assumed)			Wald chi2(1) =0.04			
			Prob > chi2 =0.8464			
Spices Area	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
year	11.17542	57.69311	0.19	0.846	-101.901	124.2518
_cons	-21096.8	116338.6	-0.18	0.856	-249116	206922.7

Table 19. The R-squared numbers (within = 0.0000, between = 0.0000, total = 0.0003) show that there is no difference that can be explained within or between the groups. The model does not detect a relationship between the group-specific effects and the independent variable (Corr (unit, X) = 0), as shown with a p-value of 0.8464 and Wald chi-square of 0.04. The absence of any statistically significant information in the model is evident from this. The "year" variable has a margin of error of 57.69311 and a coefficient of 11.17542. The results show that there is no effect that is statistically significant (p=0.846, z=0.19). As a constant term, there is no discernible result (p = 0.856). (cons), which is -21096.8 and has a large standard error of 116338.6. Both the "year" coefficient and the constant have 95% confidence ranges that are very large amounts of uncertainty about the intercept.

Hausman test:

Table 20 Hausman Test

Dependent variable	p-value	Chi-square test	Test of summary
Spice Area	>0.05	>0.05	Random effect

Table 20. The p-value exceeds 0.05, which means we accept the null hypothesis. This indicates that the random effects model more adequately represents the data, as the individual effects do not correlate with the independent variables. Therefore, the random effects model is favored based on these findings.

Table 21 Regression

Spices Production	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
year	120.2223	547.8492	0.22	0.827	-968.513	1208.958
_cons	-227986	1104739	-0.21	0.837	-2423423	1967450

Table 21. According to the regression analysis for spice production, the variable "year" had led to a 120.22-point coefficient, 547.85-point standard error. There is no statistical significance (p = 0.827) with a t-value of 0.22. A 95% confidence interval for this number shows that there is a lot of variation in how "year" affects the production of spices. There is no statistical significance for the _cons constant term, with a t-value of -0.21, a standard error of 1104739, and a coefficient of -227986. This model can't accurately predict the link because the confidence range for the constant term is very large, spanning from -2423423 to 1967450.

Table 22 Fixed Effect Model

Fixed-effects (within) regression		Number of obs =90	
Group variable: id		Number of groups =9	
R-sq:		Obs per group:	

within = 0.0010			min =10		
between = .			avg =10		
overall = 0.0005			max =10		
corr(u_i, Xb) = -0.0000			F(1,80) =0.08		
			Prob > F =0.7751		
Spices Production	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]
year	120.2223	419.4067	0.29	0.775	-714.424 954.8682
_cons	-227986	845734.4	-0.27	0.788	-1911052 1455079

Table 22. Based on 90 observations split into 9 groups of 10, the fixed-effects (within) regression model was calculated. With an R-squared value of 0.0010 for within, 0.0010 for between, and 0.0010 for total, this model does not capture much variation in spice production between the groups. The study shows no statistically significant correlation with the model and time invested in cultivating spices ($t=0.29$, $p=0.775$). ($p=0.08$) (0.7751). The coefficient for the year variable is 120.2223 and standard deviation of 419.4067. The t-value is -0.27, the p-value is 0.788, and the constant term standard error (_cons) is 845734.4. The findings were determined to be statistically insignificant. Large confidence bands for both factors show that the predictions are inaccurate.

Table 23 Random Effect Model

Random-effects GLS regression			Number of obs =90		
Group variable: id			Number of groups =9		
R-sq:			Obs per group:		
within = 0.0000			min =10		
between = 0.0000			avg =10		
overall = 0.0005			max =10		
corr(u_i, X) = 0 (assumed)			Wald chi2(1) =0.08		
			Prob > chi2 =0.7744		
Spices Production	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]
year	120.2223	419.4067	0.29	0.774	-701.8 942.2443
_cons	-227986	845741.1	-0.27	0.787	-1885608 1429636

The random-effects GLS regression model, with 90 observations spread across nine groups, shows that the R-squared values are 0.0000 within and between groups, with a value of 0.0005 for the whole set. The least, most, and average observations per group are all 10. The "year" variable does not correlate with the group effects. The p-value of 0.7744 and a Wald chi-square value of just 0.08 show no statistical significance. The standard error for the "year" variable is 419.4067, and the coefficient is 120.2223. Its z-score of 0.29 and p-value of 0.774 cannot be considered significant. The 95% confidence interval for the year coefficient is -701.8 and 942.2443, which includes zero, indicating the true effect of year on spices production could possibly be zero indicating no relevant effects.

Discussion

The research observed a trend in agricultural land and its use over the years. For the purposes of fruit production, the regression predicts that the area allocated for growing fruits has been shrinking at an average rate of about 138 units per year, which is still not an important statistical finding. This shows that the variables in the data are not sufficient to draw firm conclusions, which helps to explain the decreasing trend. The fixed effects model confirms the trend and shows a statistically significant decline of -138.05 units per year. However, the random effects model supports the downward trend while only explaining 2.69% of the variance in the dependent variable. Random effects model would be a better model for this data according to the Hausman test (Gil-García & Puro-Cid, 2014), which means a need to account for unobserved factors into consideration when calculating fruit area. A regression study of fruit output indicates that the year has no significant effects on fruit production, indicating the complexity of agriculture trends in this field.

There is a positive correlation between the year and the area of land set aside for vegetable growing, among other crops. The regression analysis results indicate that though the level of significance is low, the area

increases by 186 units per year. The trend for both fixed and random effects models is statistically significant, which means that vegetable area has increased constantly over different time periods. According to Fajar et al. (2020), the F-statistics of both the FEM and REM indicate the model's validity and show a significant relationship. The positive influence of the year on vegetable production is supported in regression models by the coefficient of 1886.023 units per year, indicating a substantial rise in vegetable production. However, despite a strong correlation, both the models of R-squared values are rather low, suggesting that certain variable factors are not covered in the study. The Hausman test has indicated the need to adopt random effects models for fruits and vegetables.

Likewise, in spices, the regression analysis results show that the year coefficient does not have a significant impact on the spices area. The p-value for the fixed and random effects models, which is above the acceptance level, indicates that the year has no statistically significant impact on the spice areas. The Hausman test results suggest that the random effects models are a better fit and appropriate for analyzing the data.

Contribution and Implication of the Research

The study contributes significantly to expanding our understanding and focuses on highlighting the complexity of land uses in horticultural sectors like fruits, vegetables, and spices. The study offers a valuable understanding of the dynamic trends of land use and an understanding of nuances carried out by using econometric models like regressions, fixed effects models, random effects models, and the Hausman test.

Using multiple analytical models helps provide a robust understanding of the underlying factors affecting land use and make appropriate decisions. This study contributes to the current body of literature by evaluating the relationship between land areas and production, which are imperative in making choice decisions by the farmers. The study shows the use and applicability of this technique for future decision-making choices.

The study identifies the unobserved variable factors that are important in influencing the results. It suggests that future researchers and policymakers should consider not only the historical data but also take into account various external factors (socio-economics, market demand, climate) that may influence future land use decisions. The horticulture sector encounters various challenges like market structure, geographical discrepancies, sinking of arable land, urbanization, and economic concerns (Basa & Sahu, 2021; Nabi & Bagalkoti, 2017). This analysis would help in decision-making processes in a more rational manner and suggest the most appropriate combinations of factors that should be used for more robust study.

Recommendation

1. Unobserved variable:

From both the fixed effects and random effects analysis, the study indicates the exists of unexplained variability, the future study should identify and make into account for unobserved variables that influence the agricultural sectors. This could be from factors like government policies, land use, consumers preferences. These could give a deeper insight in to the study for more accurate of agriculture dynamics.

2. Enhance cross regional studies:

To better understand the variation and trends of the development of horticulture growth, cross regional comparison could help provide valuable insights on how others factors like economic factors, land development and agricultural activities. It can also help us to understand how each region adapt to certain challenges when it comes to agricultural development.

3. Participation of stakeholders in decision making:

In order to have a quality and reliable source of data, farmers, agricultural businesses and local stakeholders should be involved. This will help us to capture accurate information and valuable context to the study.

Conclusion

The study carried out for different types of horticulture crops (fruits, vegetables, and spices) leads to the conclusion that the land use and production of agriculture development are dynamics that is rather complex and determined by multiple variables, which remain unexplored in the current study. It is accepted that some of the changes, for instance, the area under fruit production, are decreasing, whereas the vegetable areas have been gradually increasing, but these changes are not always statistically significant or completely substantiated by the available data. According to the Hausman test random effects model is appropriate for analyzing the data.

Nonetheless, the low R-squared and high standard errors suggested that an extensive study of agricultural trends is yet to be developed in this area.

Limitation and Future scope

This study, like many other researches, is not free from limitations despite the proper care being taken. First, this study relies on the available data for land area and production by statistical models without analyzing the causal factors that can influence the results, such as climatic, socio-economic factors, technological incorporation, market volatility, and geographical elements, to evaluate long-term development patterns in horticulture. To better understand the various factors that influence the trend of agricultural land use and production variations, the study calls for incorporating wider factors that may help understand the influence on agricultural patterns. Future research can incorporate these factors to better understand how horticulture development is affected over an extended period.

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Community Participation in Rural Tourism- A Study in Nameri National Park, Assam

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Abstract

The local people or the communities living in the forest villages of Nameri National Park are directly or indirectly involved in rural tourism. Offering a variety of goods and services to visitors or tourists coming to the park, local people take part in the activities of rural tourism. Local people showcase their beautiful culture in terms of dance and music, tradition, ethnic food, lifestyle etc. in front of the tourists. 60% respondents strongly agreed that community participation in tourism is providing substantial financial assistance to local people. 43% of the people strongly agreed that socio-cultural development is taking place due to community involvement. Communities are able to generate additional revenue during the tourist season, which is the off-agricultural season, by participation in rural tourism. 61% respondents strongly agreed that the local communities of Nameri National Park are getting an alternative livelihood option from community participation in rural tourism.

Keywords: Rural tourism, Nameri National Park, Assam

Introduction

Rural tourism is responsible for the sustainability of a protected area, places with natural beauty. Rural tourism can grow in tourist friendly environment (Das, 2001). Prime goal of rural tourism is to modernize by minimizing the poverty of the rural people (Holland et al., 2003). Rural tourism is dependent on the nature, so it is very much necessary of conservation of nature or the nature based rural tourism resources. Conservation is helpful in the sustainability of the rural tourism for future (Honey, 2008). Rural Tourism is heterogeneous in nature and also linked with modification of the economy of an area (Sharpley and Sharpley, 1997). The increase of ethnic tourism, ecotourism, biodiversity conservation, and rural area development are all attributed to rural tourism (Potter and Burney, 2002). Rural tourism as tourism activities highlight local history, heritage, arts and crafts, and culture, as well as attractions that are primarily found in rural areas, benefiting the local community (Ruiz-Real et al. 2020). The attitudes, actions, and abilities of locals and company owners are just as significant as a destination's physical resources, particularly when it comes to developing competitive tourism offerings and experiences (Hogstrom, et al., 2010). Rural tourism is an example of sustainable tourism and "sustainable tourism through the development of its many forms of concrete manifestation, ensures the natural and economic integrity of the environment and rationally capitalizes on natural and cultural resources, but retains the necessary potential for future generations and is practically identified with a dynamic equilibrium of supply and demand, which outlines any modern tourist market" (Kataya, 2021). Natural rural environment might quietly modify regional cultural norms (Xu and Sun, 2020). In rural tourism development, the participation of people is always necessary. Without participation, it is not possible to grow rural tourism in an area. The participation will be of two types- direct (Owning camps, providing adventure sports etc. to the tourists) or indirect (providing raw materials of food to the eco-camps etc.) (Vivanco, 2002). Forecasting people's preferences and alternative choices, and whether different choices could yield quantitative indicators of the relative significance of the features of tourist destinations, goods, or services, to determine travelers' readiness to pay for different services (Raffaelli et. al, 2022). Community involvement creates several opportunities for locals and permits employment in sustainable tourism (Inskeep, 1994). By creating jobs, community involvement in tourism boosts household incomes and eventually contributes to the growth of the tourism industry (Cole, 2006).

Local communities engaged in tourism have been urged to encourage the growth of tourism in their communities on numerous occasions (Simmons, 1994). The idea that locals' participation in tourism-related activities will affect their attitudes and perceptions of the industry is further supported by Caneday and Zeiger (1991). The degree of local knowledge regarding tourists, tourism, and its effects is referred to as community knowledge about tourism, or local tourism awareness. (Saarinen, 2010). Economic development, humanitarian attitudes, the environment, social values, and knowledge are some of the variables that influence the growth of rural tourism (Poostchi, 1986). Local residents who are informed about tourism development initiatives can lower the poverty rate in their area (Zapata et al., 2011). This is the case because people who are aware of the

costs and advantages of tourism will be able to identify them (Andereck et al., 2005). Participation in decision-making, knowledge exchange, and community commitment are all examples of community involvement, which will ultimately lead to visitor satisfaction and the growth of sustainable rural tourism. (MacDonald & Jolliffe, 2003). Community involvement is essential to maintaining the growth of rural tourism. (Gursoy & Rutherford, 2004; Nicholas et al., 2009). The World Tourism organization notes that within 2025--2030, range of products on offer to tourists seeking the rural experience is to increase significantly. There is a clear trend in growth of rural tourism. India's vast, rural diversity and heritage offer tremendous potential for tourism in rural areas. Approximately 75% of rural residents of India are involved in rural tourism. Rural tourism is a significant source of income for people living near rural areas (Chaudhry and Gupta, 2010). Rural tourism in India is envisioned to generate employment opportunities, sustainable livelihood for the local community (Kar and Sahoo, 2016). Rural tourism is observed in many protected areas including Nameri National Park in Assam, India. Situated in the foothills of eastern Himalayas, Nameri National Park is famous for scenic beauty and wildlife. Identification and documentation of issues related to community participation in rural tourism in the park is not available. The objective of the present work is to study community participation in rural tourism and related issues in Nameri National Park Assam, India.

Methodology

Study Area: The area of Nameri National Park is 137 km². The national park extends from latitudes 26°51' N to 27°04' N, and longitudes 92°39' E to 92°59' E in the Sonitpur district of Assam, India (Fig 1). The nearest airport is Saloni and the park is 36.5 km away from Tezpur, district head quarter. The park was declared as wildlife sanctuary in 1985, as a national park on 15th November 1998 and also as a tiger reserve in 2000. The park is characterized by abundant rich tropical evergreen, wet deciduous, cane, bamboo semi-evergreen forests and grassland. Ecotourism, adventure tourism, ethnic tourism, and other types of rural tourism are all practiced by the residents of Tarazan village and Dharikati forest village, located in the buffer zone of the national park. Tourists visit Nameri National Park mainly in the months of September, October, January, February, March and April. The villages located in the buffer zone of the park are well-known for a variety of adventure sports, including as bird watching, river rafting, trekking, and fishing. Although agriculture is the main source of income for maximum families, local people look at rural tourism as a source of income after farming, i.e., between October and March. Rural tourism has become a viable alternative source of revenue for the local communities.

Dharikati and Tarazan villages are selected for present study (Fig 2). Since population as well as number of people engaged in rural tourism are more in these two villages. There are 210 and 860 residents in Tarazan and Dharikati villages respectively. To collect information from the villagers, structured interview schedule was made. The researcher randomly chose one adult respondent from one family. There were 120 responses from Dharikati Village and 90 from Tarazan Village.

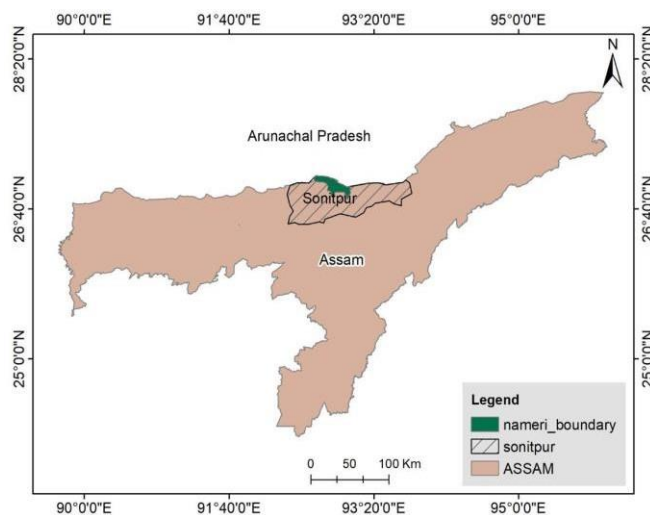


Fig1: Map of Assam showing Nameri National Park

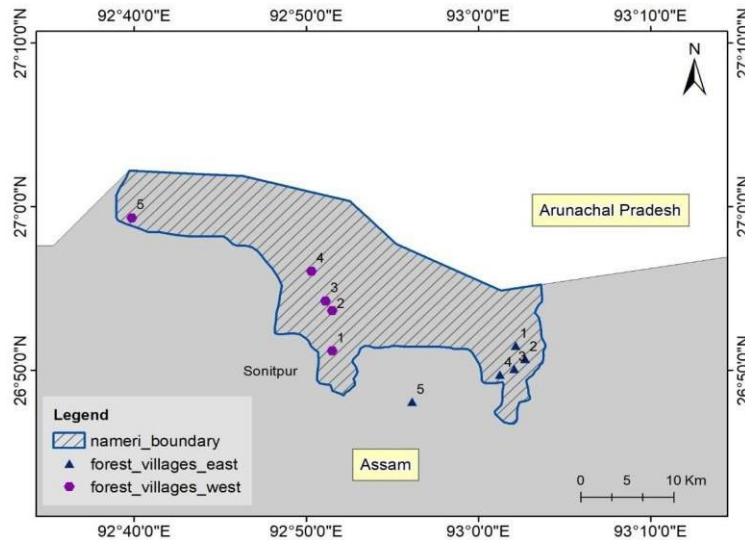


Fig 2: Map of Nameri National Park and forest villages

(Western Forest Villages: 1. Dharikati Village 2. Tarazan Village 3. Sotai Village 4. Gamani Village; **Eastern Forest Village:** 1. Selaikhati Karbi Village 2. Selaikhati Bengali Village 3. Selaikhati Kachari Village 4. Morisuti Missing Village 5. Sikham Taungya Village)

Variable Identification:Following variables related to the community participation were identified:

- Villagers' Involvement (VI)
- Villagers' problem (VP)
- Rural tourism Potentialities (RTMP) and
- Villagers' Satisfactions (VS)

The above mentioned identified variables are dependent on the some parameters which are given in Table 1.

Table 1: Variables, Parameters and the statements against Villagers' Involvement, Rural tourism Potentialities and Villagers' Satisfactions

Sl. No	Variables	Parameters	Statements
1.	Villagers' Involvement (VI)	VI1	You are involved to the park directly or indirectly
		VI2	You are socially developed due to community participation
		VI3	The socio- cultural involvement is increasing due to rural tourism
		VI4	By community participation, you are showing the Assamese tribal or non- tribal food, culture, tradition, cloth, language etc in front of tourists
2.	Villagers' Problem (VP)	VP1	You are facing many problems from the tourists.
		VP2	You also faced many challenges in the lockdown.
		VP3	You also faced problems after the lockdown.
3.	Rural Tourism Potentialities (RTMP)	RTMP1	Rural tourism is showcasing the cultural landscape of the area

		RTMP2	The tourists visit the villages frequently
		RTMP3	Community participation is also there
		RTMP4	Rural tourism is the alternative livelihood option for the villagers
		RTMP5	By adopting certain steps, the inflow of tourists to the park can be increased
		RTMP6	The cultural landscape is beneficial factor for the development of rural tourism in the park
4.	Villagers' Satisfactions (VS)	VS1	You are getting many benefits from rural tourism
		VS2	You are satisfied with the tourists' behavior.
		VS3	The development of rural tourism is minimizing the financial problems
		VS4	You are satisfied with the present condition quality of the transport service
		VS5	You are satisfied with the inflow of the tourists
		VS6	You are happy by the amount of income generated by rural tourism

To establish the relationship between variables and the parameters, researcher has calculated the weightage of the independent variables through 5 point Likert Scale from the responded through structured questionnaire distributed among the villagers during the period of May 2023 - October 2023. The relations between variables and parameters had been calculated by using SPSS software.

Results and discussions

Demographic pattern of the villagers

There are 860 numbers of people living in Tarazan and Dharikati village, out of which 628 are in Tarazan village and 232 are in Dharikati village.

210 respondents (one adult from one family) were approached with the questionnaire. There were 88 respondents from Dharikati village and 122 respondents from Tarazan village. Out of the respondents, 53 (25%) are female, and 157 (75%) are male. There are 58 respondents (28%) are between the ages of 21 and 30; 122 respondents (58%), are between the ages of 31 and 40; 26 respondents (18%) are between the ages of 41 and 50; 12 respondents (4%) are between the ages of 51 and 60; and 2 respondents (1%) are from more than 60 years. In case of educational qualifications of 210 respondents, 159 are under-metric, 44 are metric (10th standard) passed, and only 7 are higher secondary (10+2 level) passed (Fig 3). 23 families (11%) rely on government employment as their primary source of income, 21 families (10%) rely on private employment as their primary source of income, and 15 families (7%) rely on other enterprises as their primary source of income. 96 families, i.e., 46% of the total, agriculture is their primary source of income. For 55 families (26% of 210 families), tourism is their main source of income (Fig 4). Annual income of 99 families is than one lakh rupees a year. 105 families earn between two and three lakhs rupees per year, while 6 families earn between four and five lakhs rupees.

Out of the 210 families of the respondents, 111 (47%) are actively involved in the park, while 99 (53%) are indirectly involved (Fig 5). Level of involvement of villagers are different. 99 people work in management, 55 sell clothes, 75 sell various traditional items, 95 work as employees in lodging facilities, 20 run their own lodging facilities, 59 work in adventure tourism, 30 work as tourist guides, 75 work as guides, and 75 work in other capacities (Fig 6). Contribution of family income of respondents from involvement in tourism are shown in Figure 7. 58 families earn 41%–60%, 49 families earn 61%-80%, and 28 families earn 81% -100% of total income from tourism.

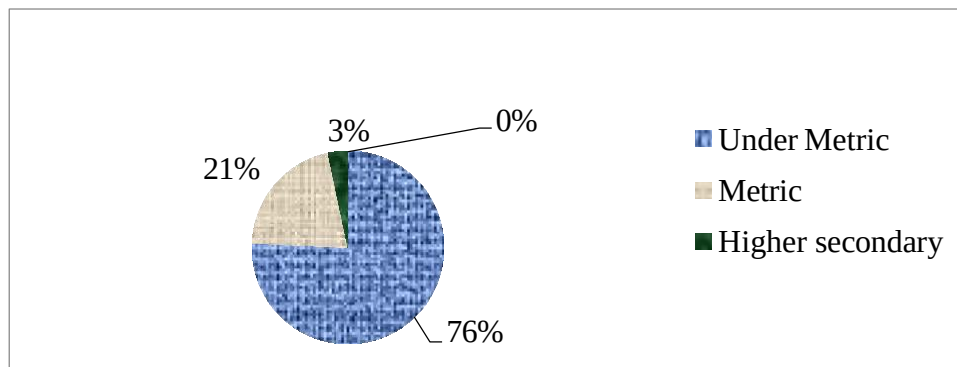


Fig 3: Respondents' educational qualification

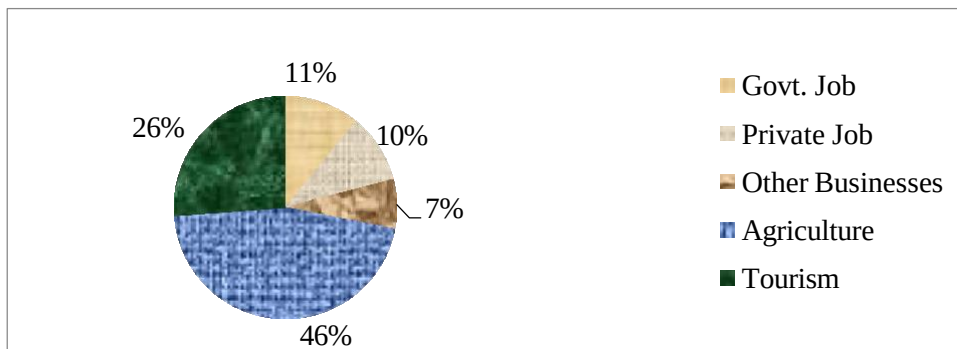


Fig 4: Prime livelihood of the families

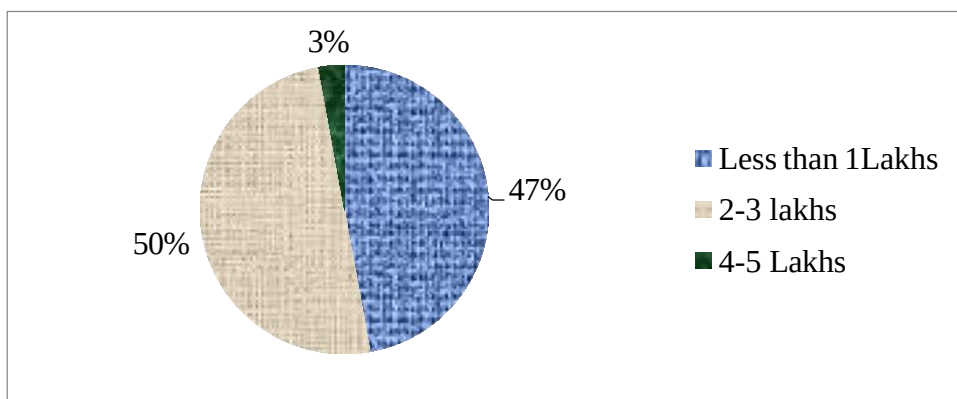


Fig 5: Yearly income of the families (in rupees)

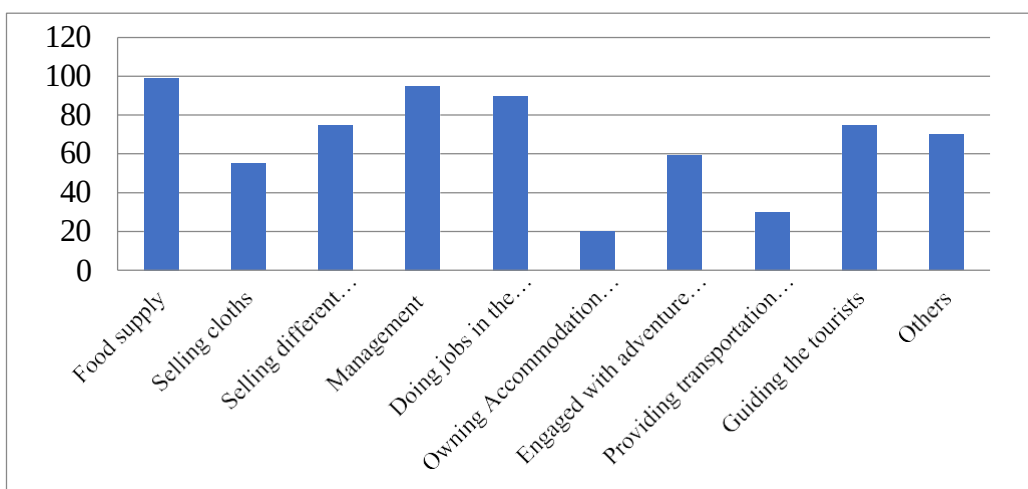


Fig 6: Different ways of earning money from rural tourism

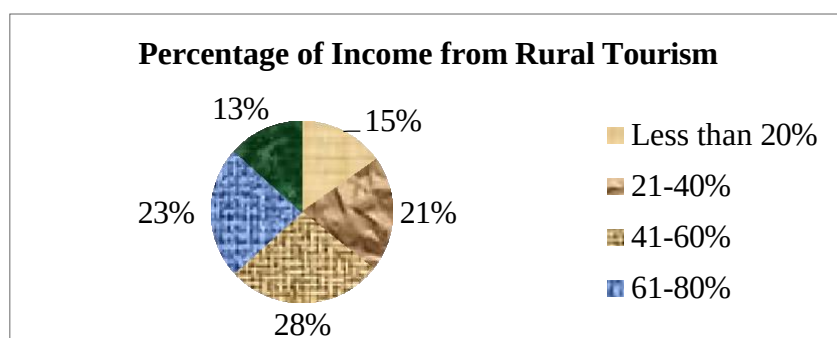


Fig 7: Income from rural tourism in percentage

Involvement of the Villagers in rural tourism:

The people living in the villages of Tarazan and Dharikati are either directly or indirectly involved in the tourism industry; they run eco-camps, sell or supply the camps with raw materials, guide visitors, help tourists in adventure sports, etc.

The value of the mean of parameters VI1, VI2, VI3 and VI4, are almost same. It ranges from 4.59 (for VI1 and VI4) to 4.61 (for VI2). The differences are not big as the respondents are only 210 (Table.2).

Table 2: Table for frequency and mean of the variable ‘Villagers’ Involvement’

	Villagers’ Involvement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Frequency	V1	0	1	4	80	125
	VI2	0	2	1	85	122
	VI3	2	14	31	73	90
	VI4	0	0	1	84	125
Parameters	VI1	VI2	VI3	VI4		
Mean	4.59	4.61	4.60	4.59		

- 125 respondents, or 59.52% of the 210 respondents, strongly agreed with statement VI1, which reads, "You are involved to the park directly or indirectly."
- The statement VI2, which reads, "You are socially developed due to community participation," was highly agreed with by 122 respondents (58%).
- The statement VI3, "The socio-cultural involvement is increasing due to rural tourism," was highly agreed with by 90 respondents (42.85%).
- The statement VI4, which reads, "By community participation, you are showing the Assamese tribal or non-tribal food, culture, tradition, cloth, language etc. in front of tourists," was strongly agreed with by 125 respondents, i.e., 59.52% of the sample.

Problems and Challenges in Rural Tourism

With the development of science and technology, the rural tourism is also developing day by day. Due to this development, different types of problems have occurred in the regions of the rural tourism destinations. Those problems are like social, environmental. So, it is very much necessary to develop the rural tourism in a sustainable way. The mean value for VP1,VP2 and VP3 are almost same and it ranges from 4.11 to 4.56(Table3).

Table 3: Table for frequency and mean of the variable Villagers' problem

	Villagers' Problem	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Frequency	VP1	0	1	4	80	125
	VP2	0	2	1	85	122
	VP3	2	14	31	73	90
Parameters	VP1	VP2	VP3			
Mean	4.56	4.54	4.11			

- The statement, "You are facing many problems from the tourists," was highly agreed with by 59.52% of the respondents. Due to congestion, pollution of the villages, etc., some tourists occasionally cause issues for the locals.
- The statement, "You also faced problems in the lockdown," was highly agreed with by 58.09% of the responders.
- The statement, "You also faced problems during and after the lockdown," was highly agreed with by 125 respondents. The rural tourism industry was completely shut down during the lockdown, which caused mental and financial difficulties to the locals also.

Potentialities of Rural tourism of Nameri National Park

There are different types of potentialities rural tourism like developing community participation, development of cultural landscape etc. The mean value for all the parameters RTMP1, RTMP2, RTMP3, RTMP4, RTMP5 and RTMP6 are almost same that it ranges from 2.24 to 4.70 (Table: 4).

Table 4: Table for frequency and mean of the variable Rural Tourism Potentialities

	Rural Tourism Potentialities	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Frequency	RTMP1	0	0	6	78	126
	RTMP2	0	0	4	85	121
	RTMP3	0	0	3	73	134
	RTMP4	0	0	4	78	128
	RTMP5	0	1	3	77	129
	RTMP6	0	0	3	74	133
Parameters	RTMP1	RTMP2	RTMP3	RTMP4	RTMP5	RTMP6
Mean	4.42	4.62	4.68	2.24	4.70	4.46

- Of the 210 respondents, 124 (60%) strongly agreed with the RTMP1 statement, which reads, "Rural tourism is showcasing the cultural landscape of the area."
- The statement RTMP2, "The tourists visit the villages frequently," was strongly agreed with by 121 respondents.
- Of the 134 responders (63.8%) strongly agreed with the RTMP3 statement, "Community participation is also there."
- The statement RTMP4, "Rural tourism is the alternative livelihood option for the villagers," was highly agreed by 128 respondents (60.95% of the sample).
- The RTMP5 statement, "By adopting certain steps, the inflow of tourists to the park can be increased," was highly agreed by 129 respondents (61.42%). There is need of some initiatives to attract more tourists and development of rural tourism in the study area.
- The statement "The cultural landscape is beneficial factor for the development of rural tourism in the park" was highly agreed by 133 respondents (63.33%).

Benefits and satisfaction of the respondents

The tourists benefit the villagers in a variety of ways, including socially, psychologically, and financially. Villagers' satisfaction is shown in Table 5.

Table 5: Table for frequency and mean of the variable Villagers' Satisfaction

	Villagers' Satisfaction	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Frequency	VS1	0	0	0	80	130
	VS2	0	0	5	66	139
	VS3	0	0	3	87	120
	VS4	50	79	79	2	0
	VS5	0	0	6	82	122
	VS6	0	0	7	76	127
Parameters	VS1	VS2	VS3	VS4	VS5	VS6
Mean	4.61	4.63	4.55	2.15	4.55	4.57

- Of the 210 responders, 131, or 62.38%, strongly agreed with the statement VS1, which reads, "Rural tourism offers numerous advantages."
- The statement VS2, "You are satisfied with the tourists' behavior," was strongly agreed with by 140 respondents, or 66.66%.
- The statement VS3, which reads, "The development of rural tourism is minimizing the financial problems," was strongly agreed with by 120 respondents, or 57.14%. The statement VS4, "You are satisfied with the present condition quality of the transport service," was not strongly agreed with by any responder.
- The statement VS5, "You are satisfied with the behavior of the tourists," was highly agreed with by 122 respondents, or 58.09%.
- The statement VS6, which reads, "You are happy by the amount of income generated by rural tourism," was highly agreed with by 126 respondents, or 60% of the sample.

Conclusion

The local community of study area is either directly or indirectly involved in rural tourism. Rural tourism brings the visitors to the unique culture and society of the local communities. The result is an increase in socio-cultural participation. Community participation in rural tourism of the Nameri National Park helps the tourists to know about the environmental, social background of the area. 61% respondents strongly agreed that due to the community participation in rural tourism, the local communities of Nameri National Park are getting an alternative livelihood option. Community participation is helping the local communities to showcase their beautiful culture, tradition, food habit, lifestyle, dance music etc. in front of the tourists. Community participation also helps the tourists to know about rural tourism potentialities of the forest villages of the park. 60% respondents strongly agreed that community participation in tourism is providing financial assistance to local people. 43% of the people strongly agreed that socio-cultural development is taking place due to community involvement. It is often recognized that rural tourism in forest settlements needs to be developed to attract more tourists.

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The Impact of Workspace Aesthetics on Employee Emotions in Government Education Institutions with Special References to Bilaspur District

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Abstract

This study examines the impact of workspace aesthetics, perceived comfort, functionality, and trust in organizational support on employee emotional well-being in government education institutions, with a specific focus on the Bilaspur district. Using a purposive sampling method, a sample of 397 employees was selected to ensure representation across teaching, administrative, and support staff roles. Data were collected through a structured questionnaire employing a 5-point Likert scale to measure key constructs such as workspace aesthetics, perceived comfort, trust in organizational support, and emotional well-being. The findings reveal that aesthetically pleasing workspaces, characterized by well-designed layouts, calming colors, and appropriate lighting, significantly enhance employees' emotional well-being by reducing stress and fostering a sense of satisfaction and motivation. Perceived comfort and functionality emerged as critical mediators in this relationship, highlighting the importance of ergonomic furniture, spacious layouts, and task-oriented designs. Furthermore, trust in organizational support—manifested through an institution's commitment to employee welfare—was found to amplify the positive effects of workspace aesthetics on emotional health. These findings underscore the need for government institutions to prioritize aesthetic and functional workspace enhancements as part of their employee well-being initiatives, despite potential budget constraints. However, the study's cross-sectional design limits the ability to track long-term effects, and reliance on self-reported data may introduce biases. Future research could address these limitations by adopting longitudinal methods to explore the sustained impact of workspace aesthetics and by incorporating advanced design elements such as biophilic features and smart technologies. Expanding the scope to private institutions and other organizational contexts would further enrich the understanding of how workspace design influences employee emotions and productivity.

Keywords: Workspace Aesthetics, Employee Emotions, Government Education Institutions, Perceived Comfort, Organizational Support.

Introduction

Creating a supportive and aesthetically pleasing workspace is increasingly recognized as vital to employee satisfaction and productivity. For government education institutions, where employees often engage in complex and demanding tasks, an attractive, well-designed workspace can significantly influence emotional well-being and job satisfaction. Research indicates that elements like natural light, ergonomic design, colour schemes, and spatial organization contribute to a positive work environment by reducing stress and improving mood (Park & Lee, 2021). In public sector institutions, which may face budgetary constraints, understanding the specific factors within workspace aesthetics that impact employee emotions can be valuable for maximizing available resources.

Workspace aesthetics influence not only individual mood and mental well-being but also organizational outcomes such as productivity and employee retention (Chung & Park, 2022). For instance, a study by Lee et al. (2023) demonstrates that employees with access to aesthetically pleasing, ergonomic workspaces show a 15% increase in job satisfaction and a 12% decrease in stress-related absences. Such findings underscore the relevance of workspace aesthetics as an important, though often overlooked, determinant of emotional well-being in government institutions.

Given the increasing emphasis on employee well-being, this study investigates how workspace aesthetics—elements like design quality, lighting, and spatial arrangement—influence employee emotional health. Additionally, it examines perceived comfort and functionality as well as trust in organizational support, both of which are essential in creating a holistic environment that supports positive emotions. This research contributes to a growing body of knowledge on the role of aesthetics in enhancing employee experience and provides actionable insights for government education institutions to improve the well-being of their workforce.

Literature Review

Workspace Aesthetics and Employee Emotions

Workspace aesthetics encompass factors like design quality, lighting, spatial organization, and colour schemes, all of which have been found to influence employee emotions and job satisfaction. According to research, workplace aesthetics have a big influence on employees' overall well-being and happiness. The research indicates that employees' opinions of their workplace and organisation are more influenced by the aesthetic elements of office design than by the practical ones (Danielsson, 2015). Job satisfaction, sense of safety, and time spent at work are all positively impacted by an aesthetically beautiful workplace (Barton & Le, 2023). Employee well-being in hotels is positively impacted by design features like Unity and Variety; front stage personnel report more aesthetic enjoyment than backstage staff (Kirillova, Fu, & Kucukusta, 2018). Compared to ergonomic demands, aesthetic needs in the workplace are more commonly reported and are linked to musculoskeletal discomfort, sleep disruptions, psychologically taxing job, and stress (Schell, Theorell, & Saraste, 2011). Enhancements to workplace aesthetics, such as the addition of artwork, plants, and natural lighting, can improve worker happiness and wellbeing (Barton & Le, 2023). These results highlight how crucial it is to take aesthetics into account when designing a workplace in order to support worker happiness and wellness.

It was found that biophilic design, which integrates natural elements such as plants and natural lighting, significantly reduces stress and fosters a sense of calm in the workplace (Mehta et al., 2022). Similarly, it was highlighted the positive impact of aesthetic design on emotional well-being, showing that employees who worked in visually appealing environments reported higher satisfaction and engagement levels (Lin and Chang, 2021).

Furthermore, it was found that visual elements such as colour schemes and natural lighting can influence emotional responses, with cooler colours and ample lighting associated with improved mood and productivity, (Zhang et al., 2022). This is especially relevant in government education institutions, where employees often face bureaucratic stressors, and workspace aesthetics can serve as a buffer against emotional strain.

Perceived Comfort and Functionality

Perceived comfort and functionality play a vital role in determining how employees experience their workspace. According to the study, comfortable seating, ergonomic furniture, and adequate space for tasks positively influence job satisfaction and lower stress levels (Wang and Chen, 2022). Their study noted that employees who perceived their workspaces as comfortable and functional reported a 25% increase in productivity.

According to research, employees' experiences at work are greatly influenced by perceived comfort and functionality. Cell offices have the greatest ratings for workplace design, whereas hot desks receive the lowest (Danielsson & Theorell, 2019). Perceived productivity is significantly impacted by concentration capacity; workers who are happier with their ability to focus report being more productive (Maarleveld & Been, 2011). Architecture's aesthetic qualities frequently surpass its utilitarian components in influencing how people view the workplace and the organisation (Danielsson, 2015). However, personal traits are quite important when it comes to acoustic comfort. One important factor is noise sensitivity; those who are more sensitive report higher levels of disturbance and worse acoustics (Roskams, Haynes, Lee, & Park, 2019). Furthermore, open-plan workplaces tend to be less pleasant for employees who are less interactive (Roskams, Haynes, Lee, & Park, 2019). These results imply that in order to maximise comfort, contentment, and productivity, workplace design should take into account both physical features and unique personnel traits.

In education institutions, where employees frequently work long hours and handle diverse tasks, comfort and functionality are essential. The research emphasized that functional workspaces with well-organized layouts promote efficiency and decrease fatigue, particularly in high-demand environments (Kim and Cho, 2021). Additionally, their findings suggest that investing in functional improvements like adjustable seating and spacious layouts can significantly enhance employee well-being.

Trust in Organizational Support

Trust in organizational support involves employees' belief that their organization values and prioritizes their well-being. It was found that employees who perceived their institutions as supportive showed increased job satisfaction, loyalty, and emotional stability (Tsai et al., 2023). In government education institutions, this trust becomes especially critical given the demanding work environments. It was noted that employees in supportive institutions reported greater resilience to work-related stress, as organizational support creates a psychological safety net that enhances overall morale (Johnson and Park, 2023).

Furthermore, it linked organizational support with a positive work climate, finding that environments that visibly prioritize employee comfort and well-being strengthen trust, resulting in a more committed workforce (Rashid and Zimring, 2022). This relationship underscores the importance of institutional investments in workspace enhancements to build a sense of trust and support among employees.

Employee Emotional Well-being

Emotional well-being in the workplace is a comprehensive construct involving satisfaction, stress levels, and motivation. When work environments are visually appealing, supportive, and functional, employees tend to experience higher levels of emotional well-being. A study found that emotionally satisfied employees exhibit greater engagement and productivity, which is critical in sectors like education where job demands are high (Singh and Sirdeshmukh, 2020).

A key component of both organisational results and employee well-being is trust in organisational support. Employees' perception that their company appreciates their efforts and is concerned about their welfare is known as perceived organisational support, or POS (Eisenberger & Stinglhamber, 2011) (Rhoades & Eisenberger, 2002). Fairness, supervisor support, and positive work environments all have an impact on POS (Rhoades & Eisenberger, 2002). It lowers turnover intentions while improving performance, emotional commitment, and work satisfaction (Kurtessis, et al., 2017) (Stefano, Venza, Cascio, & Gaudiino, 2018). Team support is a better indicator of well-being and work satisfaction than organisational support, according to research that separates the two levels of trust and support (Stefano, Venza, Cascio, & Gaudiino, 2018). According to research it was found that, employees' conviction in the organization's discretionary actions, feelings of duty, satisfaction of socio-emotional needs, and performance-reward expectations all contribute to the link between POS and good outcomes (Rhoades & Eisenberger, 2002). All things considered, encouraging POS is essential to preserving long-lasting employer-employee relationships in the unpredictable workplace of today (Eisenberger & Stinglhamber, 2011).

In addition, identified that employee well-being is enhanced by workplace aesthetics that align with organizational values, which in turn positively influences performance outcomes. Given that government education institutions rely on employee dedication to maintain service quality, fostering an emotionally positive environment is vital for achieving organizational goals (Patrick and Hagtvædt, 2022).

Objective of The Study

Based on the literature review, we draw the following objectives:

- To find the impact of Workspace aesthetics on employee emotional well-being
- To find the influence of Perceived comfort and functionality on employee emotional well-being
- To find the effect of Workspace aesthetics on Perceived comfort and functionality
- To find the effect of Workspace aesthetics on organizational support

Hypothesis

Following hypothesis is formulated from the proposed objectives

H1: Workspace aesthetics positively impact employee emotional well-being.

H2: Perceived comfort and functionality positively influence employee emotional well-being.

H3: Trust in organizational support positively affects employee emotional well-being.

H4: Workspace aesthetics positively affect perceived comfort and functionality.

H5: Workspace aesthetics positively affect trust in organizational support.

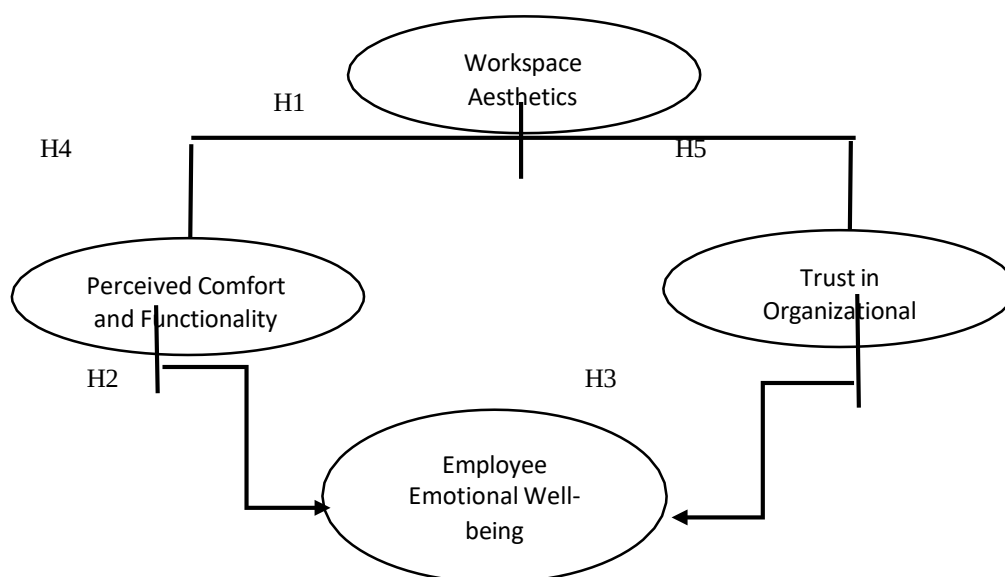


Figure 1: Diagrammatic presentation of hypothesise

Source: Self-made using MSWord

Research Methodology

The study surveyed 397 employees in government education institutions special reference Bilaspur district of Chhattisgarh state. The sample included a mix of administrative, teaching, and support staff, with demographic details provided in Table 1.

Table No. 1: Demographic Details of Respondents

Demographic Category	Frequency	Percentage
Gender		
Male	210	52.9%
Female	187	47.1%
Age Group		
21-30	142	35.8%
31-40	178	44.8%
41-50	58	14.6%
51+	19	4.8%
Education Level		
Bachelor's Degree	136	34.3%
Master's Degree	201	50.6%
Doctorate	60	15.1%
Employment Type		
Administrative Staff	152	38.3%
Teaching Staff	153	38.5%
Support Staff	92	23.2%
Master's Degree	201	50.6%
Doctorate	60	15.1%
Employment Type		
Administrative Staff	152	38.3%

Source: Self-calculated based on primary data collected by the authors.

Table I provides an overview of the demographic characteristics of the respondents. The sample is relatively balanced in gender, with a slight majority of males (52.9%) over females (47.1%). The largest age group represented is 31–40 years (44.8%), followed by 21–30 years (35.8%), indicating that a substantial portion of the participants are mid-career professionals. Most respondents hold a Master’s degree (50.6%), and the largest employment type category is administrative staff (38.3%). These demographics suggest a diverse sample representative of the workforce in government education institutions, providing relevant insights into the influence of workspace aesthetics on various employee categories. Sampling Tools and Techniques

Determination of Sample Size: The sample size was determined using Cochran's Sample Size Formula, which specifies that a sample size of at least 385 is adequate for hypothesis testing with a desired confidence level (1.96) and margin of error (0.05) (Cochran,1977). A total of 397 employees working in government education institutions in the Bilaspur district were included in the study, ensuring the sample exceeded the required threshold for robust analysis.

Cochran formula for estimating sample size when population is unknown:

$$n_0 = Z^2 \cdot P \cdot (1-P) / e^2$$

Where n_0 : Sample size, e : Margin of error, P : the fraction of the population (as percentage) that displays the attribute and z : the z-value, extracted from a z-table

Sampling Technique for Data Collection: The study employed purposive sampling to select participants from the population. This technique ensured the inclusion of a diverse mix of teaching, administrative, and support staff to provide comprehensive insights. Data were collected using a structured questionnaire designed on a 5-point Likert scale, which helped ensure consistency and reliability in measuring constructs such as workspace aesthetics, perceived comfort, trust in organizational support, and employee emotional well-being.

Exploratory Factor Analysis (EFA) Results

An EFA was conducted to assess the underlying structure of the data and to ensure each construct was appropriately measured. The table below shows factor loadings for each item within the constructs.

Table No. 2: EFA Factor Loadings and T-Values for Workspace Aesthetics, Perceived Comfort, Trust, and Emotional Well-being

Variable	Item Description	Factor Loading	T-value
Workspace Aesthetics			
WA1	Design and decor are visually pleasing	0.72	3.15
WA2	Workspace has appropriate lighting	0.78	3.72
WA3	Layout supports ease of movement	0.81	4.11
WA4	Colours and ambiance are calming	0.69	3.40
Perceived Comfort			
PC1	Workspace furniture is comfortable	0.65	3.50
PC2	Sufficient workspace for tasks	0.70	3.65
PC3	Workspace layout promotes productivity	0.75	3.95
PC4	Ergonomically suitable equipment	0.77	4.10
Trust in Organizational Support			
TOS1	Institution provides supportive environment	0.73	3.45
TOS2	Institution values employee well-being	0.76	3.55
TOS3	Institution prioritizes safety and comfort	0.80	4.05
Employee Emotional Well-being			
EEW1	I feel motivated to work	0.71	3.50
EEW2	Workspace positively affects my mood	0.73	3.60
EEW3	I experience lower stress levels due to workspace aesthetics	0.69	3.40

Source: Self-calculated based on primary data collected by the authors using SPSS AMOS

The table II presents the results of an Exploratory Factor Analysis (EFA) for four constructs: Workspace Aesthetics, Perceived Comfort, Trust in Organizational Support, and Employee Emotional Well-being. Each construct demonstrates strong factor loadings, indicating that the items are good indicators of their respective factors, with T-values exceeding 3.0, confirming statistical significance. Notably, items such as "layout supports ease of movement" and "ergonomically suitable equipment" stand out for their high loadings, emphasizing their

critical role in enhancing workspace aesthetics and comfort. Overall, the findings underscore the importance of these factors in fostering trust and emotional well-being among employees, suggesting that organizations should prioritize thoughtful workspace design and supportive environments.

Measurement and Reliability Testing

The study used a 5-point Likert scale to measure the constructs. Reliability and validity were tested using Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE) values, as shown in Table II.

Table No. 3: Reliability and Validity of Constructs

Construct	Cronbach's Alpha	Composite Reliability	AVE
Workspace Aesthetics	0.83	0.85	0.63
Perceived Comfort	0.81	0.84	0.60
Trust in Organizational Support	0.78	0.80	0.58
Employee Emotional Well-being	0.79	0.82	0.61

Source: Self-calculated based on primary data collected by the authors using SPSS AMOS

Table III presents the Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE) values for each construct: Workspace Aesthetics, Perceived Comfort, Trust in Organizational Support, and Employee Emotional Well-being. All constructs demonstrate strong internal consistency, with Cronbach's Alpha values above 0.78, which exceeds the commonly accepted threshold of 0.70 for reliability. Composite Reliability values are also above 0.80, further confirming the reliability of each construct. The AVE values for each construct exceed 0.50, which confirms adequate convergent validity, suggesting that each construct explains more than half of the variance of its indicators. These results indicate that the constructs are both reliable and valid for measuring the intended variables.

Table No. 4: Discriminant validity was confirmed using the Fornell-Larcker Criterion.

Construct	Workspace Aesthetics	Perceived Comfort	Trust in Org. Support	Emotional Well-being
Workspace Aesthetics	0.79			
Perceived Comfort	0.62	0.77		
Trust in Org. Support	0.54	0.59	0.76	
Emotional Well-being	0.65	0.63	0.60	0.78

Source: Self-calculated based on primary data collected by the authors using SPSS AMOS

Table IV uses the Fornell-Larcker Criterion to assess discriminant validity, which ensures that each construct is distinct from others. The values in the diagonal cells represent the square roots of each construct's AVE, and each of these is higher than the correlations with other constructs in the corresponding rows and columns. This finding indicates strong discriminant validity, meaning that each construct—Workspace Aesthetics, Perceived Comfort, Trust in Organizational Support, and Employee Emotional Well-being—captures a unique dimension of the overall model. Therefore, the constructs are appropriately measured as distinct components, contributing to the robustness of the study.

Confirmatory Factor Analysis (CFA) and Measurement Model

Confirmatory Factor Analysis (CFA) was conducted to validate the measurement model, assessing the fit and structure of the hypothesized constructs. Key fit indices indicate an acceptable model fit: the Root Mean Square Error of Approximation (RMSEA) is 0.078, the Comparative Fit Index (CFI) is 0.970, and the Tucker-Lewis Index (TLI) is 0.908. These values are within acceptable ranges, with RMSEA below 0.08 and CFI and TLI above 0.90, confirming that the model aligns well with the observed data. The CFA results support the hypothesized structure of the constructs, showing that the indicators are valid measures of Workspace

Aesthetics, Perceived Comfort, Trust in Organizational Support, and Employee Emotional Well-being. Additionally, significant factor loadings for each item ($p < 0.05$) further confirm the validity of the indicators within their respective constructs.

Measurement Model

The measurement model establishes that each construct is reliably measured by its associated indicators, confirmed through tests of reliability, convergent validity, and discriminant validity. As demonstrated in Tables 2 and 3, the measurement model achieves high reliability (Cronbach's Alpha and Composite Reliability values above 0.70), convergent validity (AVE values above 0.50), and discriminant validity (Fornell-Larcker Criterion). These findings indicate that the measurement model adequately captures the theoretical constructs and that each construct is both unique and statistically distinct from others. The strong model fit in the CFA, along with the robustness of the measurement model, confirms that the study's instruments are appropriate for examining the relationships between workspace aesthetics, perceived comfort, organizational support, and employee emotional well-being.

Structural Model and Hypothesis Testing

The structural model tested relationships among variables, confirming a good model fit. The results, shown in Table 4, indicate support for all hypotheses.

Table No. 5: Path Coefficients and Hypothesis Testing

Hypothesis	Path	Coefficient (β)	p-value	Result
H1	Workspace Aesthetics → Emotional Well-being	0.23	< 0.05	Accepted
H2	Perceived Comfort → Emotional Well-being	0.40	< 0.05	Accepted
H3	Trust in Org. Support → Emotional Well-being	0.17	< 0.05	Accepted
H4	Workspace Aesthetics → Perceived Comfort	0.58	< 0.05	Accepted
H5	Workspace Aesthetics → Trust in Org. Support	0.51	< 0.05	Accepted

Source: Self-calculated based on primary data collected by the authors using SPSS AMOS

Table V displays the path coefficients (β values) and significance (p-values) for each hypothesized relationship in the structural model. All hypotheses are supported, as evidenced by significant p-values ($p < 0.05$) and positive β values. Specifically, Workspace Aesthetics has a significant impact on Employee Emotional Well-being ($\beta = 0.23$), indicating a direct effect of workspace design on emotional health. Similarly, Perceived Comfort and Trust in Organizational Support significantly influence Employee Emotional Well-being, with β values of 0.40 and 0.11, respectively. Furthermore, Workspace Aesthetics strongly affects both Perceived Comfort ($\beta = 0.60$) and Trust in Organizational Support ($\beta = 0.67$), demonstrating that a well-designed workspace positively shapes employees' perceptions of comfort and support. These results validate the model's hypotheses and suggest that workspace aesthetics, comfort, and organizational support collectively foster positive emotional outcomes for employees.

Discussion

The findings from this study confirm the hypotheses, highlighting the significant role of workspace aesthetics, perceived comfort and functionality, and trust in organizational support in shaping employee emotional well-being within government education institutions. Workspace aesthetics, in particular, emerged as a primary

driver, directly influencing perceived comfort and trust, which subsequently enhanced employee emotional well-being. This relationship underscores the importance of aesthetic design in the public sector, where creating a supportive environment can positively impact employee morale, satisfaction, and productivity.

The findings align with past studies, that emphasized the role of aesthetics in reducing stress (Mehta et al., 2022), and, it was also demonstrated that functional workspaces improve satisfaction (Kim & Cho, 2021). In this study, aesthetically pleasing elements—such as colour, lighting, and layout—contributed to a perception of comfort and support, ultimately fostering a positive work environment. These results suggest that government institutions could benefit from allocating resources toward aesthetic and functional improvements in workspaces, despite potential budget constraints.

Additionally, this study highlights the critical role of trust in organizational support. When employees feel that their well-being is a priority, they report higher levels of job satisfaction and reduced stress. These findings support the conclusions of, reinforcing the idea that institutional support can buffer employees against the stressors inherent in government education roles (Tsai et al., 2023). Establishing this trust is particularly essential in public institutions, where a positive work climate can help offset the emotional demands placed on employees.

Conclusion

This study demonstrates that workspace aesthetics, perceived comfort, and trust in organizational support significantly influence employee emotional well-being in government education institutions. Aesthetic elements like lighting, colour, and spatial organization enhance perceived comfort and functionality, which in turn promote a positive emotional response among employees. Trust in organizational support further amplifies this effect, providing employees with a sense of stability and motivation.

These findings have valuable implications for government education institutions, suggesting that investment in workspace aesthetics and functionality can yield considerable benefits in employee satisfaction and productivity. By prioritizing workspace aesthetics and fostering a supportive environment, these institutions can create a work culture that not only reduces stress but also promotes emotional well-being and resilience among employees.

Practical Implications

The study provides actionable insights for government education institutions aiming to improve employee emotional well-being. Implementing cost-effective aesthetic improvements, such as optimizing lighting, organizing workspaces for functionality, and incorporating nature-inspired design elements, could substantially impact employee satisfaction. Additionally, promoting a supportive organizational culture by showing a visible commitment to employee comfort and well-being can strengthen trust, resulting in a more motivated and resilient workforce.

Limitations and Future Research

This study is limited by its cross-sectional design, which prevents the examination of long-term effects. Additionally, the reliance on self-reported data may introduce response biases. Future research could adopt a longitudinal approach to examine how changes in workspace aesthetics affect employee well-being over time. Moreover, further research could explore the impact of specific aesthetic features, such as ergonomic improvements and the role of natural elements, on employee emotions in various institutional settings.

Declaration of Competing Interests

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Unveiling Key Drivers of Capital Structure: A Sectoral Study of Indian Manufacturing Firms

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Abstract

This research fills a need in the literature by examining, at the firm level, the factors that have a substantial impact on the capital structure decisions made by manufacturing enterprises in India, as opposed to developed economies. Despite extensive research on capital structure determinants in advanced markets, limited attention has been given to emerging economies like India, where the dynamics of corporate finance are influenced by unique institutional, economic, and market conditions. This research explores firm-specific factors impacting the capital structure of Indian manufacturing firms using data spanning the financial years 2010-11 to 2019-20. To ensure robust analysis, the study adopts an innovative methodological framework combining the generalized method of moments (GMM) technique and the Random Forest model, a machine-learning approach. GMM is utilized to address endogeneity issues often present in dynamic panel data, while the Random Forest model identifies and ranks the key determinants of capital structure, adding a novel dimension to the analysis. By employing these complementary techniques, the study provides deeper insights into the factors shaping leverage decisions in Indian manufacturing firms. A significant contribution of this study is its sector-wise analysis, which evaluates whether firm-specific determinants of capital structure vary across different manufacturing sectors. A more detailed comprehension of leverage decisions is provided by this method, which takes into account the fact that different sectors exhibit different financial behaviour and operational traits. Particularly for developing nations, the results highlight the need for sector-specific approaches to fiscal management and policymaking. In sum, by combining time-honoured econometric methods with state-of-the-art machine learning models, this study adds to our knowledge of the factors that influence capital structure in the Indian setting. The results offer valuable implications for corporate managers, policymakers, and investors seeking to optimize leverage decisions in dynamic and diverse market conditions. This study also lays the groundwork for future research exploring the interplay between firm-specific characteristics, sectoral dynamics, and capital structure in emerging economies.

Keywords: : Capital Structure, Corporate Finance, Firm Characteristics, Indian Manufacturing Firms, Leverage.

JEL Classification: G3, G32, L6, O16

Introduction

The decisions pertaining to capital structure of a firm have constantly been debatable. Every finance manager aims to achieve an optimal equilibrium between debt and equity in the firm's capital structure. According to Graham & Harvey, (2001) the need to preserve a certain degree of financial flexibility is a significant factor influencing corporate capital structure decisions for most chief financial officers.

The groundbreaking research of (Modigliani and Miller, 1958, 1963) The tax shield advantage and the irrelevance of capital structure have provided the groundwork for an extensive amount of empirical research and theory in the field of capital structure. These theories include the trade-off theory (Modigliani and Miller, 1958), the agency theory (Jensen and Meckling, 1976), and the pecking-order theory (Myers and Majluf, 1984). These and the other theories have been extensively established empirically, mainly in economically more developed countries (Harris and Raviv, 1991). Despite the extensive research, there is no conclusive evidence or consensus to suggest recommendations for an organization's optimal capital structure or set of rules to help financial managers strike the optimal balance between debt and equity funding. Maximizing corporate firm value while minimizing the cost of capital is the goal of every firm, which is why finding the appropriate capital structure is essential. Academics and practitioners have struggled to find the optimal debt-to-equity ratio for their respective firms. To what degree firm-specific qualities, as opposed to external influences, dictate a firm's financing decisions is one of the more pressing concerns in capital structure theory. (Rajan and Zingales, 1995; Hall, Hutchinson and Michaelas, 2004)

Many emerging economies are slowly inching towards the debt level in developed economies. However, problems with capital structure in a developing country cannot be solved by extending research done in developed countries. The level of economic development and the subsequent internal factors specific to firms that influence such decisions vary from country to country. To fully grasp the significance of firms' financing decisions in the Indian economy, India must be analysed as an isolated case. The decision to undertake this study is heavily influenced by the maturity level of the Indian economy and the distinctive set of business characteristics found in India. The present study aims to investigate the following research question:

RQ1- What are the key firm-specific attributes driving the capital structure of Indian manufacturing firms?

Objective of the Study: To identify the firm's characteristics and the degree to which they affect the firm's capital structure.

Specific Objectives of the study:

- To determine the sectoral variations of the impact of firm-specific factors on Indian manufacturing firms.
- To provide relevant insights for policymakers and corporate decision-makers concerning capital structure optimization in the Indian manufacturing sector.

Through this study, we shed some light on providing better insights into capital structure decisions and aiding financial managers in picking the right capital structure.

Most studies historically have studied capital structure decisions using panel regression models such as 'Ordinary Least Square (OLS)', 'Tobit regression', and various multiple regression models (Rajan and Zingales, 1995) and (Handoo and Sharma, 2014). More recent studies have moved to employing more advanced econometric techniques, such as the 'Generalised Method of Moments (GMM)' and 'Instrumental Variable (IV)' approaches, which are also used to address endogeneity issues in capital structure research. Studies like those by (Flannery and Rangan, 2006) (Panda and Nanda, 2020)

This study utilises panel data approximations from a sample of 577 Indian manufacturing firms spanning from 2010-11 to 2019-20. 'Profitability,' 'market-to-book,' 'firm size,' 'Tangibility,' 'growth opportunity,' 'non-debt tax shield,' 'liquidity,' and 'age of the firm' are chosen as determinants of leverage, which were built on the prevailing literature. The paper focuses on a sectoral analysis. The study aims to use a different approach compared to existing literature. The study uses the 'generalized method of moments (GMM)' and the novel approach of a 'Random Forest model,' a machine learning technique, to analyze the key determinant of capital structure.

An examination of the factors that affect capital structure at individual firms, broken down by industry, is the study's main contribution. The study found that the most significant determinants of leverage were Growth, Profitability, Liquidity and Market-to-Book Ratio; and that they vary across manufacturing sectors in India. The results of this study will hold strategic importance for finance managers in the industrial sector and policymakers in India. The remainder of this paper is structured as follows. Section 2 presents a concise literature overview. Section 3 presents the data gathered for the study. Section 4 highlights the technique adopted alongside our econometric model. Section 5 presents the empirical findings and discusses the outcomes, while section 6 concludes the study.

Literature Review

The long-running discourse over what would be considered the optimal 'capital structure' for a firm and its consequent value originates from the literature, (Modigliani and Miller, 1958) found that the value of a company does not change regardless of its capital structure, meaning that the value of enterprises that use leverage and those that do not are equivalent. The original study was based on the postulation that, tax benefits do not exist. This assumption was deemed implausible, and in their subsequent research paper, (Modigliani and Miller, 1963) takes into consideration the tax advantages that come with a firm's debt structure. They came to the conclusion that a levered firm receives value equivalent to the value of the tax benefit it receives from loan capital, and that this value is greater than that of an unlevered firm. Further study by (Kraus and Litzenberger, 1973) established that, at the macro level alone, there is an optimal capital structure and maintained that a tax shield is the most significant benefit of debt capital. The ability to subtract interest paid on debt capital from a company's gross profits before calculating its tax burden is a major factor in this. However, there are costs to raising debt capital, including bankruptcy and liquidation expenses. Finding the best financial structure requires weighing the costs and advantages.

A great deal of research in developed markets have fixated on what influences or decides the firm's capital structure. The question of whether firm-level or country-level factors influence the capital setup of a firm's decisions has also been investigated. (Psillaki and Daskalakis, 2009) determined that firm-specific factors account for variations in the intensity of capital structure decisions rather than factors at the country level. The Firm's Size, Profitability, Asset Tangibility, and Growth Potential are the four most important factors in determining the firm's capital structure, according to a study conducted by (Rajan and Zingales, 1995). Other studies by (Titman and Wessels, 1988; Barclay, Smith, and Watts, 1995; Pandey, 2001) have found that risk and investment opportunities are crucial determinants of a firm's debt structure.

In the Indian context, research on capital structure is fairly limited compared to research in developed countries. Size, asset structure, profitability, and the cost of short-term financial distress are some of the variables that might be considered when determining the ideal capital structure (Guha-Khasnobis and Bhaduri, 2002). (Pal, 2014) discovered that a non-debt tax shield and growth potential also influence a firm's capital structure. (Handoo and Sharma, 2014) asserted that tax rate and debt servicing capabilities significantly influence a firm's leverage structure. However, at the sector level, each manufacturing sector was found to have its own unique set of capital structure determinants (Panda and Nanda, 2020).

It takes a certain finesse to design a capital structure for a company (Handoo and Sharma, 2014). The firm must strike a balance between financial flexibility and discipline. It is more essential than any tax benefits for determining a firm's capital structure, and it is especially important for larger firms, which often have very little debt. A robust long-run equilibrium link is supposedly believed to exist between the capital structure of non-financial Indian firms and several key firm-specific factors (Chakraborty, 2010; Panda and Nanda, 2020).

In general, more established businesses would rather have lower levels of debt since more information about them is readily available and because they have more time to accumulate retained earnings. Firms that have more tangible assets tend to seek out additional debt, which supports the signaling hypothesis. A firm's inclination towards long-term debt financing is the sole one that diminishes as retained earnings rise, in keeping with the 'Pecking Order Theory', which states that retained profit has a significantly negative effect on the firm's debt structure (Bandyopadhyay and Barua, 2016).

Considering that research on firm-specific determinants is fairly limited in the Indian industrial sector, more studies are needed to fill the current gaps in the existing literature. More studies are needed to provide new evidence from emerging economies such as India, and more evidence on the effect of firm-specific factors and how they vary across sectors and impact capital structure decisions. Keeping this in mind, our study intends to focus on firm-specific factors that determine leverage in different industrial sectors in India.

Data for the study:

This research is exclusively empirical and utilises secondary data. The study sample comprises data from firms listed on the 'Bombay Stock Exchange (BSE)' and the 'National Stock Exchange (NSE).' Companies were chosen based on the presence of comprehensive records over a decade. The study period spans from the fiscal year 2010-2011 to 2019-2020, encompassing a duration of ten years. This study focuses on the industrial sectors in India. The firms selected for the study were classified sector-wise based on the National Industrial Classification (NIC). The study also excludes firms that have been engaged in M&As during the study period, primarily because during this period, the true picture of the firms under M&As can be inaccurate. Additionally, the sample does not include all firms that have been liquidated or stopped their operations and whose stocks are delisted in the BSE/NSE. The research additionally omits companies engaged in the banking and insurance industries. We used the CMIE Prowess IQ database to collect firm-level data for the study. The selected industrial sectors are listed in Table 1.

Table No 1: List of industrial sectors selected

Name of the industrial sector	Number of firms
Manufacture of Basic Iron and Steel	55
Manufacture of Transport Equipment	58
Manufacture of Textiles	69
Manufacture of Chemical and Chemical Products	110
Manufacture of Machinery and Equipment	36
Manufacture of Pharmaceuticals	65
Manufacture of Other Non-Metallic Mineral Products	39
Manufacture of Electrical Equipment	46
Manufacture of Food Products	40
Manufacture of Rubber & Plastic Products	59
Total	577

Source: Authors' compilation

Variables of the study:

Dependent variable

Long-term debt ratio (LTDR): One measure of a company's financial health is the ratio of its long-term debt to its total assets. Companies and industries are said to have different methods of valuations. The long-term debt ratio is classically calculated by dividing long-term debt capital by the company's total assets.

Long-term debt ratio (LTDR)= Long term debt/ Total Assets

Independent variables

This section concisely outlines the diverse factors of capital structure, as established in prior studies. The determinants include 'firm size,' 'tangibility,' 'non-debt tax shield,' 'profitability,' 'growth opportunity,' 'liquidity,' 'age of the firm,' and 'market-to-book ratio'. The hypotheses were developed from the literature, considering the factors and their relationship with capital structure for testing.

Age

An older firm's target leverage ratio will be larger, everything else being equal. Established firms have more time and experience to cultivate stronger ties with their credit providers. In addition, the firm's inventory, accounts receivable, and assets can be utilised as security for financing as it expands. A lack of collateral assets can make it much more difficult for younger firms to get external loans, which is already a difficulty due to knowledge asymmetries and possible agency issues stemming from a lack of trading history.(Berger and Udell, 1990; mac an Bhaird and Lucey, 2010; Handoo and Sharma, 2014)

H1. A firm's age is positively associated with its leverage.

Growth Opportunity

Prior research indicates that firms exhibiting more growth tend to possess a relatively lower level of leverage in their capital structure. According to(Baskin, 1989), the 'Trade-off Theory' posits that this variable has a detrimental effect, as more growth correlates with a heightened danger of bankruptcy. This indicates that a favorable effect aligns more closely with the 'Pecking-Order Theory.' Growth prospects are capital assets that significantly enhance a firm's value, although they cannot serve as collateral and do not generate current taxable income. We propose a favourable correlation between debt and growth potential based on this rationale. (Bauer, 2004; Črnigoj & Mramor, 2009; David Vicente-Lorente, 2001; Handoo & Sharma, 2014; Köksal & Orman, 2015; Malinić et al., 2013; Psillaki & Daskalakis, 2009.

H2. Growth opportunities exhibit a positive association with a firm's leverage.

Liquidity

A firm's liquidity can be defined as the speed with which it can turn its assets into cash. Companies that have a lot of cash on hand are better able to take on additional debt since they can pay back their short-term loans quickly. Accordingly, we anticipate a favourable correlation between liquidity and capital structure decisions (Malinić, Denčić-Mihajlov and Ljubenović, 2013; Handoo and Sharma, 2014; Ramli, Latan and Solovida, 2019).

H3. Liquidity is positively correlated with a firm's leverage.

Market-To-Book Ratio

The theory posits that managers strategically 'time the market' to benefit the organisation. Market timing is achievable in efficient markets for companies possessing financial flexibility. To evaluate this behaviour, we employed a market-to-book ratio identical to that utilised by (Baker and Wurgler, 2002) in our study. By dividing the security's book value by its market value, it aims to find undervalued or overvalued assets. To find out if managers try to "time the market" or if the capital structure decision takes advantage of the short-term mispricing behaviour, this proximate is found essential (Li & Islam, 2019).

H4. The market-to-book ratio is negatively related to a firm's leverage.

Non-Debt Tax Shields

A lower debt level is characteristic of a firm's capital structure that maintains an adequate amount of non-debt tax shield. Depreciation is a mechanism that companies can utilise to reduce their tax obligations without acquiring additional debt. The tax advantage of debt financing decreases when the utilisation of non-debt tax shields, such as depreciation, increases. As a result, it is expected that the non-debt tax shield will exhibit an inverse correlation with target leverage (Bauer, 2004; Guha-Khasnobis & Bhaduri, 2002; Köksal & Orman, 2015; Malinić et al., 2013; Titman & Wessels, 1988).

H5. Non-debt tax shields demonstrate a negative relationship with firm leverage.

Profitability

An increase in debt capital serves as a tax shield for a more lucrative firm. Since the cost of external financing is quite high, firms with great profitability and access to internal sources of financing are likely to favour using this source and borrowing significantly less. Less profitable businesses are more likely to take out relatively more external debt since they don't have enough money coming in from other sources. Profitability and the desired level of leverage are thus inversely related (Bauer, 2004; Črnigoj & Mramor, 2009; Guha-Khasnobis & Bhaduri, 2002; Handoo & Sharma, 2014; Köksal & Orman, 2015; Li & Islam, 2019; Malinić et al., 2013; Psillaki & Daskalakis, 2009).

H6. Profitability is inversely associated with a firm's leverage.

Firm Size

A substantial amount of research suggests a possible relationship between 'Firm Size' and leverage ratios. The main point is that larger firms have an easier time attracting long-term financing due to less severe informational asymmetries. A less likelihood of bankruptcy is associated with larger, more diversified firms. Firms with a larger market cap also have lower leverage costs since fixed direct bankruptcy expenses are a smaller percentage of market cap. When firms are larger, they are able to reap greater benefits from their assets and sales, which improves their financial performance by increasing the value of their production. Because of these factors, big companies tend to issue more debt (Bancel & Mittoo, 2004; Bauer, 2004; Guha-Khasnobis & Bhaduri, 2002; Handoo & Sharma, 2014; Köksal & Orman, 2015; Malinić et al., 2013; Psillaki & Daskalakis, 2009; Rajan & Zingales, 1995).

H7. Firm size is positively linked to leverage.

Tangibility

Increased tangible assets usually mean an increased degree of leverage for a firm. The 'Agency Cost Theory' states that a company's capital structure strategy is influenced by its total asset holdings. Firms with considerable fixed tangible assets may be perceived by creditors as having a safety net in the event of financial challenges. This is because, according to 'The Trade-Off Theory,' these assets can be used as collateral. Thus, the increase in the ratio of physical assets to total assets is seen as a positive indicator for the firm by investors (Bauer, 2004; Črnigoj & Mramor, 2009; Handoo & Sharma, 2014; Li & Islam, 2019; Malinić et al., 2013; Rajan & Zingales, 1995).

H8. Asset tangibility shows a positive correlation with a firm's leverage.

Table No. 2. Summary of the hypothesised Relationship of Independent variables with Leverage:

Firm-specific variables: (independent variables)	Relationship with leverage (positive/ negative)
Firm's Age (AGE)	Positive
Growth opportunity (GROWTH)	Positive
Liquidity (LIQ)	Positive
Market-to-Book (MTB)	Negative
Non-debt tax shield (NDTS)	Negative
Profitability (PROF)	Negative
Firm size (SIZE)	Positive
Tangibility (TANG)	Positive

Source: Authors' compilation

Research Methodology and econometric model:

Using panel data regression approaches, we determine the key factors influencing capital structure in several Indian industries. Panel data models function on the assumption that the data under study are linear, exogenous, homoscedastic, non-autocorrelated, have no evidence of multicollinearity, and are not cross-sectionally dependent. Although some of these assumptions are problematic, only if $t > 20$. Suitable diagnostics are undertaken to ensure model validity.

Generalized Method of Moments (GMM)

To study the significant determinants of a firm's capital structure, we establish a link between firm-specific variables and the firm's capital structure. In the Dynamic Panel data model below, the capital structure represented by Long-Term Leverage is depicted as a function of a group of firm-specific variables.

Dynamic Panel Regression Model:

$$Y_{it} = \alpha Y_{it-1} + \beta X_{it} + \omega_{it} + \varepsilon_{it} \quad (1)$$

Y_{it} = Dependent variable

Y_{it-1} = Lagged dependent variable

α = Autoregressive (persistence) parameter

βX_{it} = Independent Variables and corresponding coefficients

ω_{it} = Unobserved heterogeneity

ε_{it} = Idiosyncratic error term

Regression equations:

$$LTDR_{it} = \alpha LTDR_{it-1} + \beta_1 TANG_{it} + \beta_2 PROF_{it} + \beta_3 GROWTH_{it} + \beta_4 NDTS_{it} + \beta_5 LIQ_{it} + \beta_6 MTB_{it} + \beta_7 SIZE_{it} + \beta_8 AGE_{it} + \varepsilon_{it} \quad (2)$$

Where:

$LTDR_{i,t}$ = The Total Debt Ratio of a firm 'i' at time 't'

$\alpha LTDR_{it-1}$ = The lagged value of LTDR, capturing the persistence

β_1 to β_8 = different independent variables for the leverage of firm i at time t

$\varepsilon_{i,t}$ = Error term

LTDR (Long Term Debt Ratio), TANG (Tangibility), PROF (Profitability), GROWTH (Growth Opportunity), NDTS (Non-Debt Tax Shield), LIQ (Liquidity), MTB (Market to Book Ratio), SIZE (Firm size), AGE (Age of the firm).

To address potential endogeneity issues arising from the inclusion of the lagged dependent variable and other regressors, we estimate the model using the Generalized Method of Moments (GMM) (Difference GMM and System GMM) approach, following the framework proposed by (Arellano and Bond, 1991) and (Blundell and

Bond, 1998). It is a semi-parametric method of estimating the coefficients under panel data methods. This method uses lagged values of the dependent variable and other independent variables as instruments to achieve consistent and efficient parameter estimates. Dynamic panel data models also effectively handle unobserved heterogeneity, Heteroskedasticity, autocorrelation, and possible Endogeneity by including the lagged dependent variable as a regressor and mitigating omitted variable bias. All these, together, make GMM a robust method for analyzing complex panel data structures.

Generalized Method of Moments (GMM) is a complex technique and comes with its inherent set of flaws. 1st is the possible autocorrelation in the errors that is if residuals are serially correlated, the moment conditions may become invalid. This is mitigated by Performing the Arellano-Bond test for autocorrelation (AR(1) and AR(2)). For valid GMM results, the AR(1) test should show significant autocorrelation (p-value < 0.05), while the AR(2) test should show no significant autocorrelation (p-value > 0.05).

The 2nd common problem is the overfitting of instruments, which can lead to misspecification of the model, leading to biased estimates and weak identification. Limit the number of instruments relative to the number of cross-sectional units a good rule of thumb is that the instruments should not be more than 75% of the number of groups in the panel. We can also use the Hansen J test to check the validity of the instruments. A p-value that is too high might indicate overfitting. Instrument validity is established when p-value is above Roodman's common sense minimum threshold of 0.25 but < 1.0 (Roodman, 2009).

Multicollinearity Test Variance Inflation Factor (VIF)

In order to check if the linear regression model was multicollinear, the Variance Inflation Factor (VIF) was used. When the VIF is more than five, it indicates a significant amount of multicollinearity; at this point, the coefficients are considered to be poorly assessed and the p-values are cause for concern (Frost, 2019). A VIF of up to 5 was found to be acceptable by most researchers. The VIF of the variables in the study was less than five, signifying the absence of a multicollinearity issue.

Random Forest Model

The Random Forest analysis was conducted using 'Orange Data Mining' software to predict the 'Long Term Debt Ratio (LTDR),' which was set as the target variable. The models were configured with 500 trees to enhance prediction accuracy and reliability. A maximum of 5 features was considered at each split to balance model performance and computational efficiency. The tree depth was unlimited, allowing the trees to grow fully unless constrained by other stopping criteria, such as a minimum of 5 data instances required to split a node. The dataset used for the analysis consisted of firm-level indicators as independent variables which are defined as features. Additionally, company name and year were included as meta-attributes for identification but were not directly utilized in model predictions. The analysis focused on identifying key determinants influencing firms' capital structure. The model was trained with 70% of the data and was tested on the balance 30% of the data. The model training was replicable to ensure consistency, allowing the results to be reproduced across different runs. This comprehensive approach provided valuable insights into the interaction between firm-level factors and leverage in shaping debt-related decisions. The output was generated from the feature rank widget provided by 'Orange Data Mining,' which showed the most significant variables for prediction.

Empirical findings and discussion of the results

Descriptive statistics

Understanding the summary statistics of the primary variables utilised in the study is vital before evaluating the results of the econometric analysis of the firm-specific determinants of Indian manufacturing firms. This will help us obtain a better grasp of the data under consideration. The descriptive statistics, including the mean, standard deviation, minimum, and maximum, of the study's variables across all sectors are presented in Table V.

Table No. 3. Results of the descriptive analysis

Manufacture of Basic Iron and Steel					
Variable	Observations	Mean	Standard Deviation	Minimum	maximum
LTDR	550	0.1963	0.1339	0.0143	0.7131
TANG	550	0.3429	0.1420	0.0666	0.7358
PROF	550	0.0951	0.0704	-0.1742	0.4333
GROWTH	550	8.0573	19.2029	-78.7108	273.9483

NDTS	550	0.0293	0.0148	0.0054	0.0928
LIQ	550	0.0352	0.0521	0.0000	0.0521
MTB	550	1.4571	5.3173	0.0629	120.2096
SIZE	550	3.7025	1.7743	-1.9470	8.3985
AGE	550	1.6380	0.1611	1.1761	2.1461
Manufacture of Electrical Equipment					
LTDR	460	0.1272	0.0885	0.0021	0.5634
TANG	460	0.2494	0.1384	0.0242	0.7235
PROF	460	0.1111	0.0832	-0.2029	0.4774
GROWTH	460	10.5350	17.2116	36.4302	137.3380
NDTS	460	0.0241	0.0123	0.0033	0.0769
LIQ	460	0.0775	0.1265	0.0004	0.8034
MTB	460	2.7418	3.2207	0.0848	27.2833
SIZE	460	3.4206	1.6357	1.4663	6.4818
AGE	460	1.6879	0.1625	1.1461	1.9777
Manufacture of Pharmaceuticals					
LTDR	650	0.1700	0.1344	0.0050	0.6473
TANG	650	0.2903	0.1543	0.0119	0.8218
PROF	650	0.1279	0.1259	-0.2935	1.5841
GROWTH	650	13.5727	23.2460	59.7509	273.7241
NDTS	650	0.0251	0.0129	0.0030	0.0899
LIQ	650	0.0725	0.1151	0.0000	0.6890
MTB	650	2.8845	2.8995	0.1668	21.0150
SIZE	650	3.0637	2.0117	7.2989	6.6784
AGE	650	1.6362	0.1542	1.3424	2.0212
Manufacture of Textiles					
LTDR	690	0.2512	0.1415	0.0049	0.6595
TANG	690	0.3963	0.1473	0.0319	0.7005
PROF	690	0.0918	0.0599	-0.1565	0.3864
GROWTH	690	7.6864	19.2899	35.2088	288.9711
NDTS	690	0.0414	0.0248	0.0026	0.1767
LIQ	690	0.0289	0.0625	0.0002	0.5381
MTB	690	1.2708	1.5895	0.0123	21.8942
SIZE	690	3.0715	1.3728	0.2088	5.9620
AGE	690	1.6747	0.1854	1.2304	2.1206
Manufacture of Chemical and Chemical Products					
LTDR	1100	0.1867	0.1187	0.0000	0.8502
TANG	1100	0.3147	0.1582	0.0146	0.8154
PROF	1100	0.1281	0.1007	-0.3875	1.1311
GROWTH	1100	12.0150	29.7926	53.9115	724.7977
NDTS	1100	0.0268	0.0173	0.0012	0.1687
LIQ	1100	0.0498	0.0747	0.0000	0.6001
MTB	1100	2.9043	5.0717	0.1111	61.9549
SIZE	1100	3.5484	1.6161	0.9358	7.7021
AGE	1100	1.6503	0.1732	1.1139	2.1761
Manufacture of Rubber & Plastic Products					
LTDR	590	0.1817	0.1131	0.0002	0.5793
TANG	590	0.3606	0.1458	0.0300	0.7709
PROF	590	0.1094	0.0795	-0.1492	0.5846
GROWTH	590	10.1917	16.1299	28.5149	102.5542
NDTS	590	0.0373	0.0210	0.0048	0.1753
LIQ	590	0.0391	0.0611	0.0000	0.3748
MTB	590	1.8227	2.1517	0.0389	15.1706
SIZE	590	3.2073	1.6801	1.1733	7.3124
AGE	590	1.6044	0.1356	1.0792	1.9395
Manufacture of Transport Equipment					
LTDR	580	0.1701	0.0922	0.0179	0.4240
TANG	580	0.3331	0.1449	0.0413	0.7470

PROF	580	0.1180	0.0950	-0.1461	0.7118
GROWTH	580	11.8983	31.1355	-34.2580	603.5876
NDTS	580	0.0371	0.0191	0.0065	0.1108
LIQ	580	0.0336	0.0476	0.0003	0.3330
MTB	580	2.5816	2.9398	0.1268	29.7992
SIZE	580	3.9392	1.6748	0.2257	8.4987
AGE	580	1.6254	0.1537	1.1139	1.9243
Manufacture of Food Products					
LTDR	400	0.1889	0.1110	0.0062	0.6247
TANG	400	0.3563	0.1486	0.0075	0.7307
PROF	400	0.1040	0.0956	-0.1290	0.8807
GROWTH	400	10.0107	32.8429	-72.6830	568.0572
NDTS	400	0.0262	0.0169	0.0005	0.1296
LIQ	400	0.0432	0.0766	0.0001	0.6025
MTB	400	2.8158	4.3216	0.0157	28.5028
SIZE	400	3.6459	1.3943	0.6228	6.4075
AGE	400	1.7359	0.2178	1.3424	2.1106
Manufacture of Machinery and Equipment					
LTDR	360	0.1530	0.1103	0.0112	0.4536
TANG	360	0.2313	0.1262	0.0160	0.5855
PROF	360	0.1128	0.1024	-0.1366	1.4236
GROWTH	360	8.6007	18.5553	35.7109	203.6336
NDTS	360	0.0280	0.0182	0.0018	0.0979
LIQ	360	0.0780	0.0974	0.0000	0.5162
MTB	360	2.9972	2.2528	0.1430	13.6536
SIZE	360	4.0206	1.3259	0.3702	7.0263
AGE	360	1.7234	0.1736	1.0414	2.0828
Manufacture of Other Non-Metallic Mineral Products					
LTDR	390	0.2363012	0.1433979	0.006097	0.608808
TANG	390	0.4341943	0.1469248	0.012077	0.721445
PROF	390	0.1120319	0.1505308	-0.262069	2.138113
GROWTH	390	11.36031	35.73692	-52.20233	623.0554
NDTS	390	0.0370375	0.0189088	0.000882	0.148233
LIQ	390	0.0448396	0.0566421	0.000034	0.384216
MTB	390	2.326775	2.177238	0.157421	15.09061
SIZE	390	4.08243	1.824755	-3.952881	7.731651
AGE	390	1.691534	0.1663858	1.30103	2.04139

Source: Authors' computation

Regression Results of the generalized method of moments (GMM)

The table below contains the coefficient estimates of the independent variables across all sectors and their significance level. The Wald Chi2 test statistic, AR (2) Statistic and Hansen Test statistic are listed at the bottom of each column, along with the Mean VIF of each panel of the regression.

Table No. 4. Results of the generalized method of moments (GMM)

	Manufacture of Basic Iron and Steel	Manufacture of Electrical Equipment	Manufacture of Pharmaceuticals	Manufacture of Textiles	Manufacture of Chemical and Chemical Products
L.LTDR	0.7782106***	0.7978045***	0.7369416***	0.875096***	0.7683061***
TANG	0.1245242**	-0.2181531**	0.012627	-0.0081942	-0.0644849
PROF	-0.1240214	-0.242091***	-0.0800879**	-0.2379652***	-0.1136337***
GROWTH	0.0005857***	0.0015369***	0.0009462***	0.0010849***	0.0006218***
NDTS	-1.131675***	-0.1073607	0.2595537	-0.2226632	-0.1564422
LIQ	0.168744**	-0.1339569**	-0.1837533***	-0.1231336	-0.1717328**

MTB	-0.0008986***	0.0049194**	-0.0023378	-0.0035707***	-0.001062
SIZE	-0.0017522	-0.0103915	-0.0203846**	-0.0399598**	-0.0235191
AGE	0.1198553	0.0189564	-0.0443226	-0.3133459	-0.0239399
Constant	-0.1563899	0.0921452	0.183609		0.2051892
Wald chi2	6096.40	836.27	313.78	233.00	1131.49
No of groups	55	46	65	69	110
No of Instruments	33	21	29	10	33
AR(2) statistic (p-value)	-0.42(0.672)	-1.20(0.229)	-0.81(0.417)	-1.06(0.291)	-0.58(0.563)
Hansen test statistic (p-value)	24.58(0.372)	9.68(0.559)	18.78(0.471)	0.36(0.548)	17.89(0.763)
Mean VIF	1.26	1.42	1.40	1.23	1.42

Note: The figures in the enclosed parentheses are the significance of the z-statistics, where *** p < 0.01 and ** p < 0.05; p-values reported for AR(2) statistic and Hansen test statistic are at a significance level of 5%.

Source: Authors' computation

	Manufacture of Rubber & Plastic Products	Manufacture of Transport Equipment	Manufacture of Food Products	Manufacture of Machinery and Equipment	Manufacture of Other Non-Metallic Mineral Products
L.LTDR	0.6689276***	0.8338826***	0.7782278***	0.5783905***	0.9602055***
TANG	0.0120244	-0.1219728	-0.095658	-0.2015019	-0.1091255
PROF	-0.2513942***	-0.260856**	-0.1663262***	-0.3587405***	-0.2592073***
GROWTH	0.0013582***	-0.0001233	0.0005294***	0.0012034***	0.0017039***
NDTS	-0.2352474	-0.8705731**	0.4351999	-0.1135256	0.2221617
LIQ	-0.1993223**	0.010236	0.0024819	-0.1793954***	-0.0769708
MTB	0.0017437	0.0021397	-0.0026951	0.016691**	0.0014595
SIZE	0.0393402**	0.0042922	-0.0120756	0.0116166	0.0090759
AGE	0.0674537	-0.0201828	-0.2618488***	-0.2999001	0.1315299
Constant		0.1375874	0.568932	0.5669442	-0.2012855
Wald chi2	71.79	2649.49	1192.11	358.32	3561.58
No of groups	59	58	40	36	39
No of Instruments	13	24	29	24	16
AR(2) statistic (p-value)	-0.78(0.438)	0.74(0.459)	-0.25(0.801)	-0.46(0.648)	0.80(0.424)
Hansen test statistic (p-value)	4.94(0.294)	12.03(0.604)	16.86(0.600)	10.80(0.702)	7.49(0.278)
Mean VIF	1.36	1.36	1.37	1.33	1.50

Note: The figures in the enclosed parentheses are the significance of the z-statistics, where *** p < 0.01 and ** p < 0.05; p-values reported for AR(2) statistic and Hansen test statistic are at a significance level of 5%.

Source: Authors' computation

Table No. 5. Summary of the results

Industrial Sectors	Long Term Debt
Manufacture of Basic Iron and Steel	(+) TANG, (+) GROWTH, (-) NDTS, (+) LIQ, (-) MTB
Manufacture of Electrical Equipment	(-) TANG, (-) PROF, (+) GROWTH, (-) LIQ, (+) MTB
Manufacture of Pharmaceuticals	(-) PROF, (+) GROWTH, (-) LIQ, (-) SIZE
Manufacture of Textiles	(-) PROF, (+) GROWTH, (-) MTB, (-) SIZE
Manufacture of Chemical and Chemical Products	(-) PROF, (+) GROWTH, (-) LIQ
Manufacture of Rubber & Plastic Products	(-) PROF, (+) GROWTH, (-) LIQ, (+) SIZE
Manufacture of Transport Equipment	(-) PROF, (-) NDTS
Manufacture of Food Products	(-) PROF, (+) GROWTH, (-) AGE
Manufacture of Machinery and Equipment	(-) PROF, (+) GROWTH, (-) LIQ, (+) MTB
Manufacture of Other Non-Metallic Mineral Products	(-) PROF, (+) GROWTH

Source: Authors' compilation

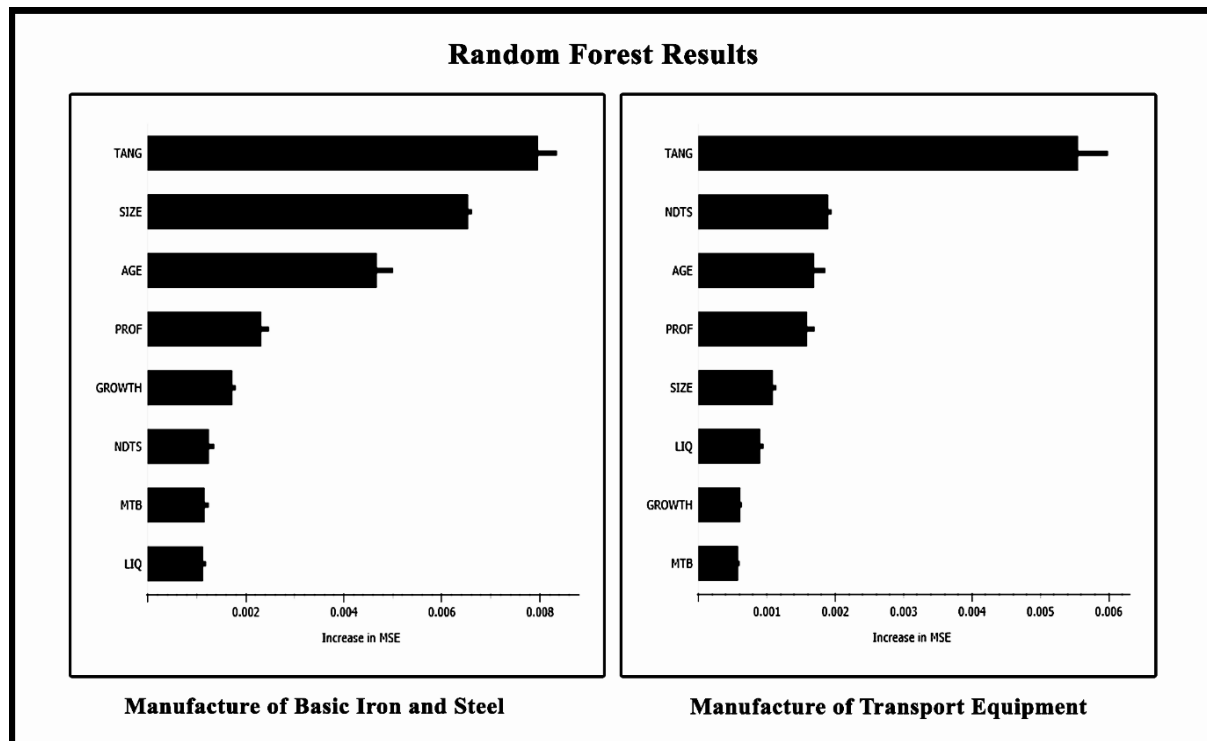
Table No. 6. Sector-wise results of hypotheses testing across Indian manufacturing firms

Hypotheses	Manufacture of Basic Iron and Steel	Manufacture of Electrical Equipment	Manufacture of Pharmaceuticals	Manufacture of Textiles	Manufacture of Chemical and Chemical Products	Manufacture of Rubber & Plastic Products	Manufacture of Transport Equipment	Manufacture of Food Products	Manufacture of Machinery and Equipment	Manufacture of Other Non-Metallic Mineral Products
H1. There is a Positive relationship between age and leverage of the firms.	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected
H2. A positive relationship exists between growth opportunities and firm leverage.	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Rejected	Accepted	Accepted	Accepted
H3. There is a positive relationship between liquidity and leverage of the firm.	Accepted	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected
H4. There is a Negative relationship between market-to-book ratio and firm leverage	Accepted	Rejected	Rejected	Accepted	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected
H5. There is a Negative relationship between non-debt tax shield and firm leverage.	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Accepted	Rejected	Rejected	Rejected
H6. There is a Negative relationship between profitability and leverage of the firm.	Rejected	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted	Accepted
H7. A positive relationship exists between firm size and leverage.	Rejected	Rejected	Rejected	Rejected	Rejected	Accepted	Rejected	Rejected	Rejected	Rejected
H8. A positive relationship exists between asset tangibility and leverage.	Accepted	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected

Results of the Random Forest Model

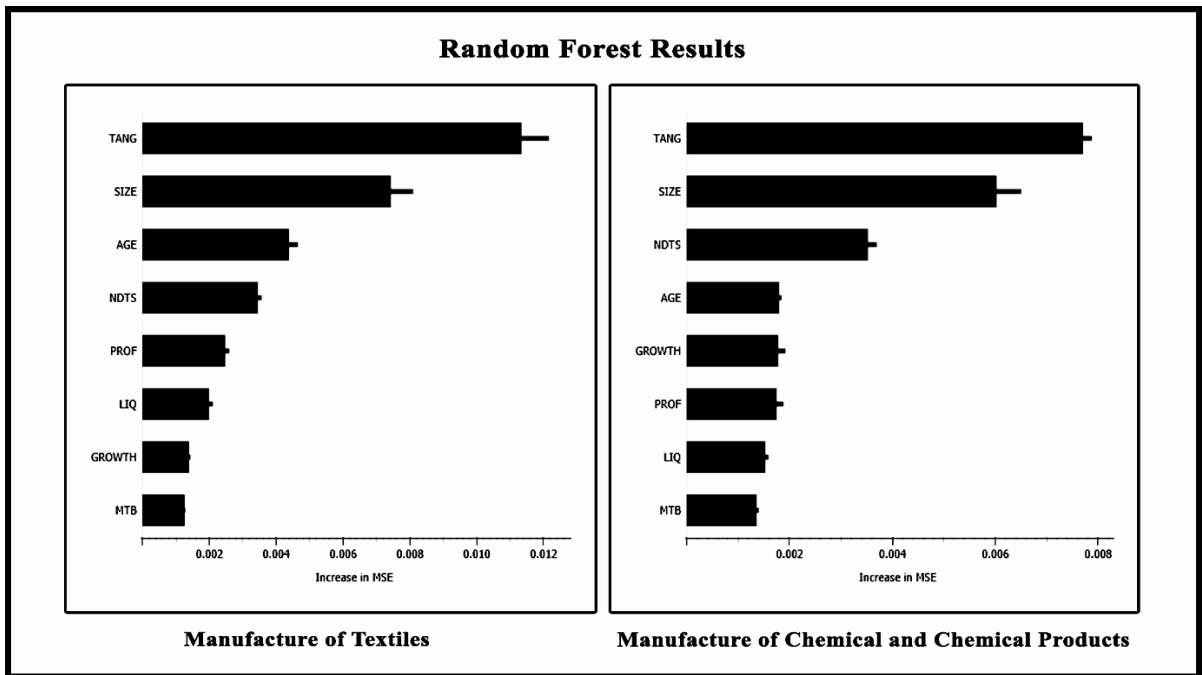
Below are the feature importance graphs generated as the output of the Random Forest Model, which shows which are the most important predictors for each of the sectors.

Figure No 1: Feature Importance Graph of Random Forest Model



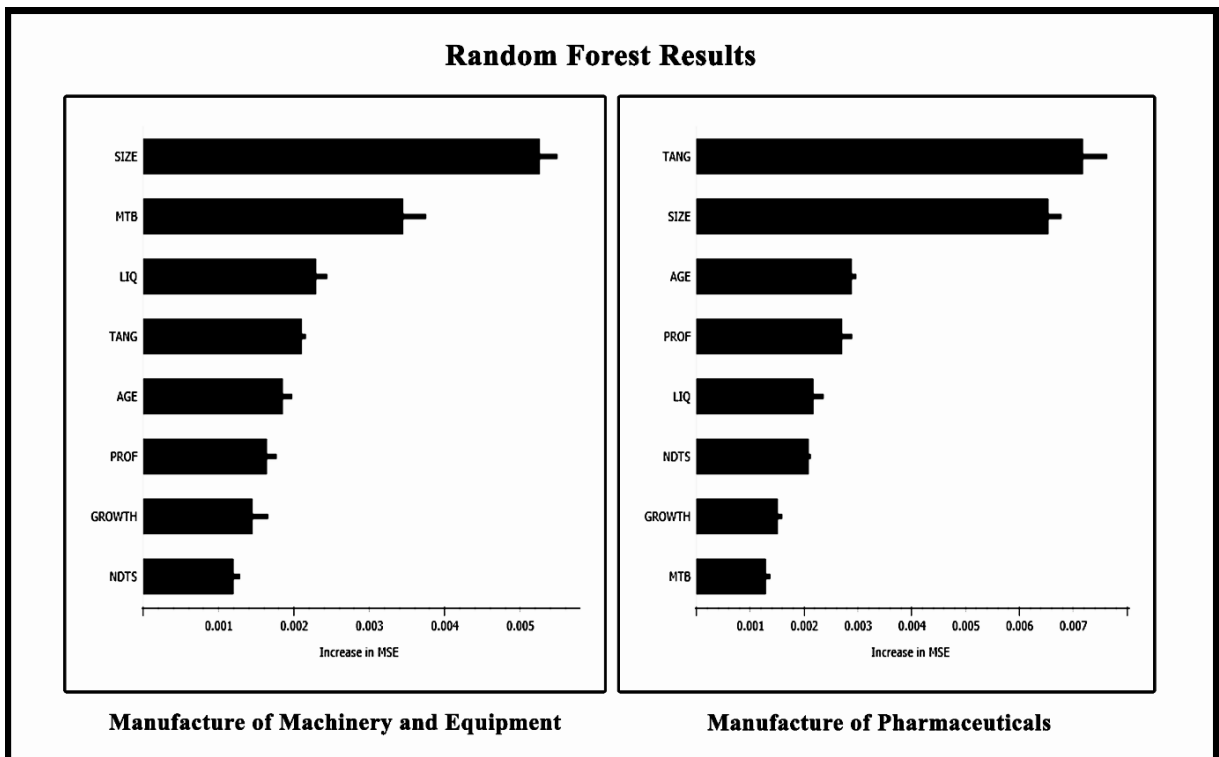
Source: Authors' computation

Figure No 2: Feature Importance Graph of Random Forest Model



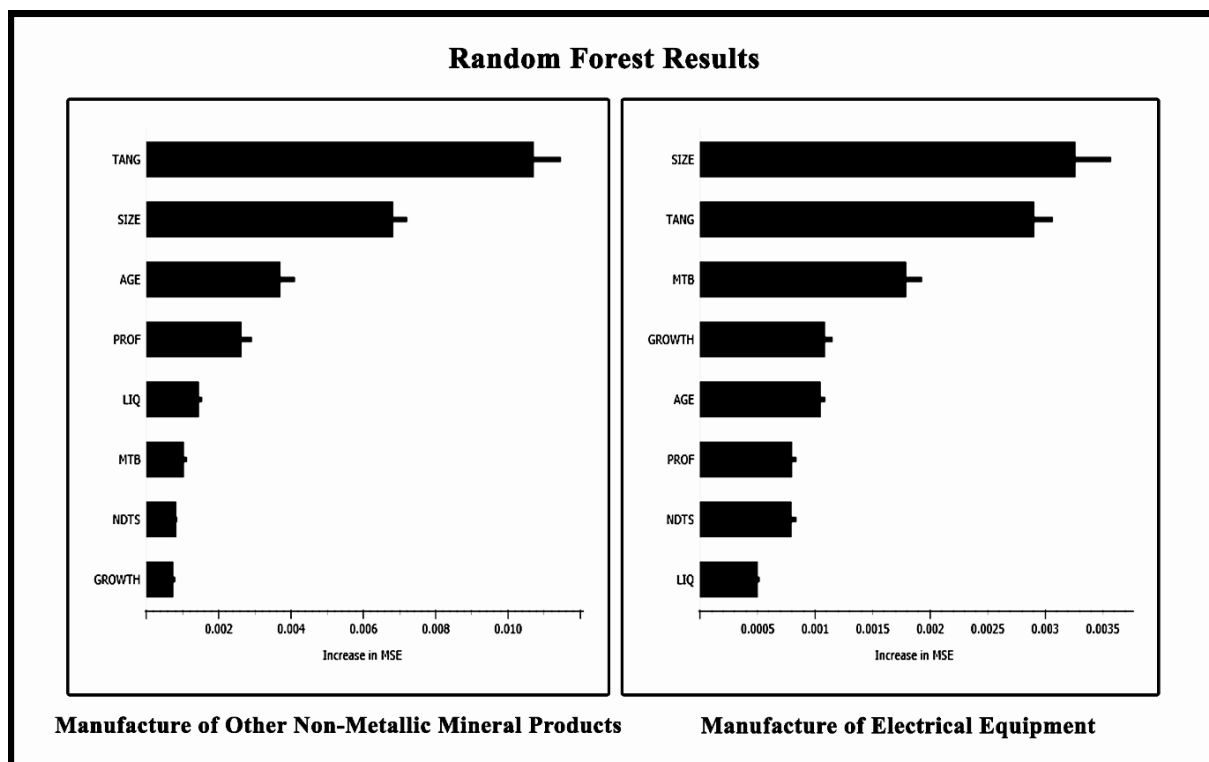
Source: Authors' computation

Figure No 3: Feature Importance Graph of Random Forest Model



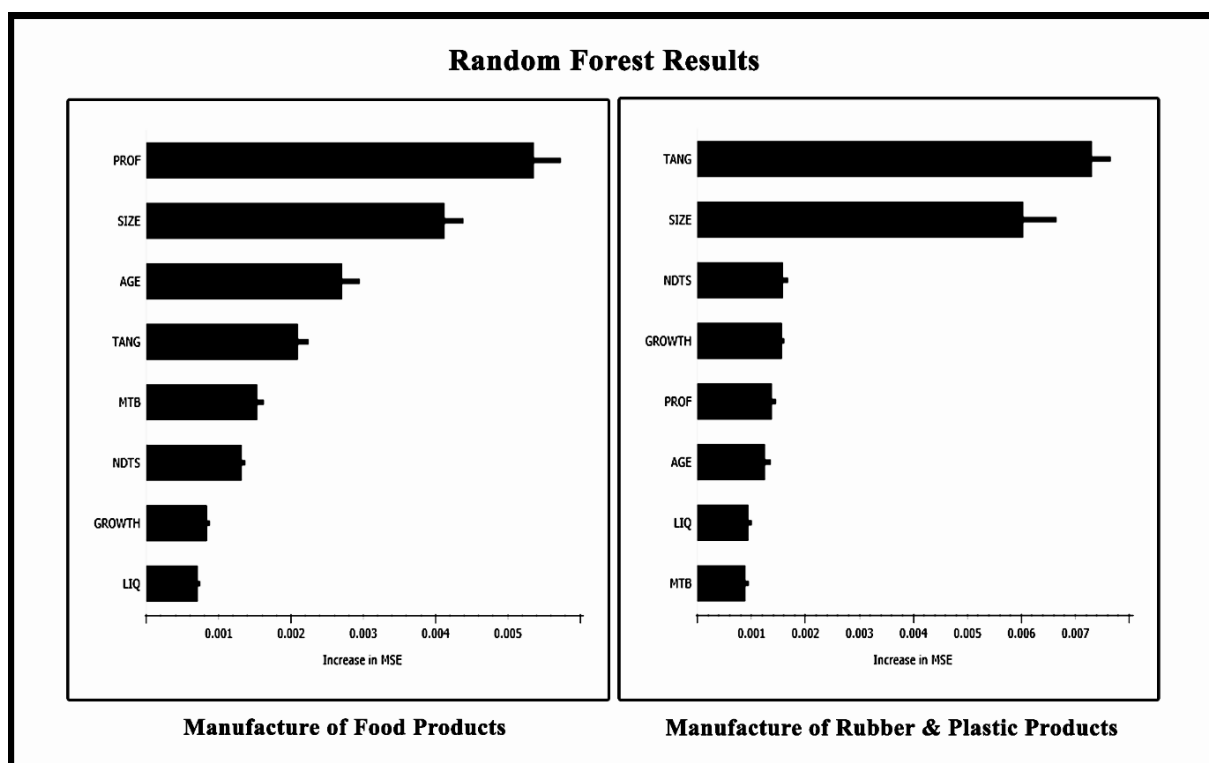
Source: Authors' computation

Figure No 4: Feature Importance Graph of Random Forest Model



Source: Authors' computation

Figure No 5: Feature Importance Graph of Random Forest Model



Source: Authors' computation

Results and Interpretation

Table No. 4 presents the dynamic panel data regression model results, Table No. 5 presents the summary of the regression results, and Figure No. 1 to Figure No. 5 presents the feature importance output of the Random Forest Model. We find that each sector has a unique set of factors that determine its leverage. Through our analysis, the

most significant leverage determinants were Growth, Profitability, Liquidity and Market-to-Book Ratio as per the regression analysis and Tangibility and Firm Size as per the Machine Learning Model. These findings are found to be in line with the international literature on the subject (Rajan and Zingales, 1995; Pandey, 2001) and as well as Indian literature (Bhaduri, 2002; Mukherjee and Mahakud, 2010; Handoo and Sharma, 2014; Ghose and Kabra, 2016). The variables found to be the least significant from the regression analysis results were Tangibility, Non- Debt Tax Shield, Size, and Age of the firm.

Our analysis found that the leverage of firms in the 'pharmaceuticals' and 'textiles' sectors declines as the size of the firm increases. A plausible reason is that larger firms exhibit greater diversification, possess a significantly reduced likelihood of encountering financial difficulties, and hence, likely to engage in higher borrowing (Li and Islam, 2019). Lower anticipated bankruptcy costs enable firms to employ more leverage (Rajan and Zingales, 1995). Leverage has a negative correlation with profitability. We found that profitability was a major factor in nearly every industry. If investments and dividends remain constant in the near future and debt financing remains the main source of outside capital, then shifts in leverage will be bound to have a negative impact on profitability. It appears that larger firms often do not issue as much equity. As a firm grows larger, the negative impact of profitability on leverage becomes more evident (Rajan and Zingales, 1995). Consistent with the Pecking Order hypothesis, which states that enterprises often favour internally generated funds over external funds to satisfy their financing needs, the coefficient of profitability is highly significant and has a negative sign (Frank *et al.*, 2003; Flannery and Rangan, 2006; Dang, Kim and Shin, 2012; Ganguli, 2013; Handoo and Sharma, 2014; Ghose and Kabra, 2016). According to the pecking order theory, this result supports the idea that capital is typically used in a way that keeps outside interference to a minimum in the operation of the business.

Capital structure theory predicts a negative correlation since high market-to-book ratios are associated with higher financial distress costs for enterprises. Companies issue equity when its price is high compared to its earnings or book value, which is another reason why the market-to-book ratio is negatively connected with leverage. The connection between leverage and the market-to-book ratio is driven by companies with a high equity ratio (Rajan and Zingales, 1995). However, the market-to-book ratios of firms, identified as significant in the electrical equipment and machinery & equipment sectors, where it positively influenced the firm's leverage, thereby contradicting the prevailing theory that asserts that the market-to-book ratio as a proxy for Market Timing, which is anticipated to have a negative correlation with leverage (Li and Islam, 2019). (Ghose and Kabra, 2016) reported an insignificant relationship between market-to-book ratio and leverage for Indian firms, which was also affirmed by our study.

While there is strong theoretical support for a non-debt tax shield as a crucial factor in determining leverage, additional empirical evidence is required to support this claim. Consistent with research conducted in the Indian context, the Non-debt tax shield was determined to be minimal in the majority of sectors with an exception of two sectors (Bhaduri, 2002), and (Titman and Wessels, 1988) who in their study also found the non-debt tax shield to be insignificant in determining the leverage of the firm. If the growth coefficient is positive, it means that companies are benefiting from increased prospects for expansion, which in turn increases their ability to take on debt (Titman and Wessels, 1988). This is also consistent with the argument (Bhaduri, 2002; Chakraborty, 2010) that In situations where information costs are more closely tied to equity difficulties, expanding businesses often turn to debt financing to fulfil their financing need.

From the capital structure theory perspective, our results are in tandem with the Pecking Order Theory; which asserts that high-growth enterprises must enhance their long-term operating assets, and our results support it. Since internal sources of funding rarely match their needs, corporations borrow significantly. Our data confirms our hypothesis that growth possibilities increase leverage across all industries. Our results are also confirmed by other empirical research findings (Titman and Wessels, 1988; Bauer, 2004; Hall, Hutchinson and Michaelas, 2004). Growth opportunities were not significant in the transport equipment manufacturing sector. This could be due to relatively high R&D costs, long product cycles, and uncertain cash flows; this sector depends largely on equity financing and retained earnings.

Surprisingly, the age of the firm was determined to be a significant determinant in only the "Manufacture of Food Products" sector, despite its significance in numerous international research. The study indicated that the longer a company has been in business, the more leverage it has and the lower the correlation it has with the amount of debt it has (Kieschnick and Moussawi, 2018). Despite being statistically insignificant across most industries, aging was determined to have an adverse impact on leverage. This is due to the fact that when businesses expand, they become well-established and are able to retain enough of their profits to fund themselves internally instead of seeking out debt.

Due to the general consensus that more liquid companies can better take on debt, most theoretical analyses of the link between the two variables find a positive correlation between them (Morellec, 2001). However, the

Pecking order theory posits that debt is bad for a company's finances and that liquid assets, such as cash on hand, could be a better option for internal financing. (Lipson and Mortal, 2009) confirmed this relationship between liquidity and leverage, showing that firms with more liquidity tend to be less leveraged. This is also true for the majority of manufacturing firms in India, and our research shows that liquidity significantly reduces leverage across many different industries.

When a firm's profits are inadequate and current cash flows fail to meet capital investments, service debt, and fulfil operating responsibilities, in the absence of alternative financing sources, firms resort to bank loans. Which is evidenced by (Chakraborty, 2010), (Malinić et al., 2013), which could also account for the statistically significant negative correlation between liquidity and financial leverage. Also, according to the Pecking Order Theory and Agency Theory, companies that are highly liquid may be less interested in seeking funding from third parties and more likely to rely on internal sources of funds (Ramli, Latan and Solovida, 2019).

The feature selection results of the Random Forest model highlight the most influential predictors in the model. Of the 10 manufacturing sectors studied, Tangibility (TANG) and Firm Size (SIZE) were the most important predictors. Tangibility was found to be particularly dominant amongst the capital-intensive sectors such as Basic Iron and Steel, Transport Equipment, textiles, and Non-Metallic Minerals, emphasizing the important role physical assets play in the financial decision of a firm. Firm Size (SIZE) was also a significant predictor in sectors such as Machinery and Equipment, Pharmaceuticals, and Electrical Equipment, reflecting the firm's economies of scale and financial stability. The variable Profitability (PROF) significantly impacted consumer-oriented sectors such as Food Products and Rubber and Plastic Products. At the same time, the Age of the firm was found to play a role in Pharmaceuticals, Iron and Steel, and Food Products, highlighting the firm's maturity and influence on its financial structure. Non-Debt Tax Shields (NDTS) were found relevant in sectors such as Chemical Products and Textiles, showcasing the significance of tax benefits. Market-to-book ratio (MTB) and Liquidity (LIQ) contribute particularly to the Machinery and Equipment and Electrical Equipment for investment signaling and working capital management. Overall, the results indicate that Tangibility (TANG) and Firm Size (SIZE) are the most universally significant predictors. In contrast, the others vary across sectors, emphasizing the need for financial strategies tailor-made to each industrial sector.

Conclusion

This research aimed to use panel data and Machine Learning methods to examine the factors that influence the capital structure of Indian manufacturing firms. This study's results provide important insight into manufacturing firms' financing operations, helping researchers to understand better the factors that impact a firm's debt and equity capital offerings and whether or not capital structure differs across different industrial sectors.

This study distinguishes itself from prior research by incorporating several crucial variables some of which have not been thoroughly examined in the context of Indian manufacturing firms. This study identified 'Growth Opportunity,' 'Profitability,' 'Liquidity,' and 'Market-to-Book Ratio (MTB)' as the primary leverage determinants across various sectors via 'Generalised Method of Moments (GMM)' analysis, while 'Firm's Size' and 'Tangibility' emerged as the most significant features according to 'Random Forest Model' analysis. This was determined to be consistent with current international and Indian literature.

The existing literature on capital structure is aligned with our study's findings. None of the three dominant theories of capital structure—"The Pecking Order Theory," "The Static Trade-Off Theory," and "The Agency Cost Theory"—can adequately describe the financial arrangements of Indian manufacturing companies. The 'Static Trade-Off Theory' and 'The Pecking Order Theory,' when taken together, provide the most satisfactory explanation for the capital structure of Indian enterprises. Instead of looking outside the company for funding, most Indian companies opt for raising funds from internal sources (Chakraborty, 2010; Chadha and Sharma, 2015). However, little evidence is available to support 'Agency Cost Theory' (Chakraborty, 2010). Studies have also (Rani, Yadav and Tripathy, 2020) provided sufficient empirical evidence to support 'Trade-Off Theory,' 'Agency Theory,' and 'The Pecking Order Theory' of capital structure in the Indian corporate sector. Our study also provides evidence to support the above narrative that no theory can explain the capital structure of Indian firms.

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Digital Transformation in Road Toll Systems: Analyzing User Perceptions of NETC Fastag in Kerala

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Abstract

According to the Global Innovation Index (2020), India ranks 48th globally in innovation and is among the top 15 countries for information and communication technology (ICT) and R&D-intensive global firms. This dynamic technological environment has enabled India to rapidly move ahead in its digital evolution, with one of the largest and fastest-growing digital consumer populations around the world. The present study looks at the technological developments within the toll collection system of India, which have seen great change from traditional manual techniques to automated and electronic systems. The Radio Frequency Identification (RFID) technology-based electronic toll collection systems, such as FASTag, have recently been launched by the National Payments Corporation of India (NPCI) in collaboration with financial institutions to address the limitations inherent in traditional modes of collecting tolls. The study provides a comprehensive overview of the toll system in India, highlighting the transition to more sophisticated technologies aimed at enhancing efficiency and user satisfaction. Data was collected from 400 users of FASTag within the Palakkad district of Kerala, enabling a detailed analysis of user perceptions regarding this contemporary tolling method. With the help of factor analysis, the study identified four key factors that affect the perception of users about National Electronic Toll Collection (NETC) FASTag. The results indicate that the efficiency, time-saving attributes, and overall convenience related to the usage of FASTag greatly improve user satisfaction. Nonetheless, the study also identifies areas that need improvement, primarily concerning technical issues experienced by users. Additionally, service accessibility plays a crucial role in shaping user perceptions, encompassing aspects such as recharging options, customer support, and the cost-effectiveness of using FASTag. Although these factors are significant, it seems that their impact on the perception of users is low as compared to the core benefits of efficiency and convenience. Therefore, these results indicate that there is a need for continuous improvement in the FASTag system so that there is smooth and user-centric tolling experience. As India advances towards adopting more digital technologies, it must work around all these barriers to facilitate further adoption across the country.

Keywords: Toll Collection, NETC FASTag, RFID Technology, Digital, User Perceptions

JEL Code: L91, O32, O33, R41, R42

Introduction

Today, technological advancements are indispensable for societal growth and adaptation. As "Necessity is the mother of invention", every technology has been built in order to meet societal demands, and as a result, it is inextricably related to the culture and behaviour of the people who inhabit the civilization. India is making notable strides in the realm of technology, positioning itself as a key player in global technological development. Despite uneven business adoption, India currently has one of the biggest and rapidly expanding digitized consumer marketplaces. An advanced knowledge economy requires a digitally empowered society. India's story of digital transformation is one of empowerment and inclusion, built on technology that is accessible, inclusive, and continuously evolving. Technology to transform a connected nation: Digital India, a report from the McKinsey Global Institute, emphasises the nation's hasty adoption of electronic technologies and their potential economic worth by 2025. If the public and commercial sectors collaborate to establish new digital ecosystems, these technologies could significantly impact the Indian economy. As part of India's Digital Transformation, the government also promotes the adoption of new technologies or upgrades while offering high-speed broadband connectivity to every nook and cranny of the nation.

The abundance of opportunities that have emerged in the world of payments over the past few years has been mostly driven by technology and digitization. The digital revolution has reshaped media, retail, and transportation industries. A new technology has been implemented in India's toll collection system with support from banks. It has been made mandatory for passengers to use that technology to cross the toll booths. A toll,

also called a toll tax, is a levy motorists must pay while navigating certain tunnels, bridges, and national and state roads. The National Highway Authority of India (NHAI) is in charge of maintaining these toll roads. By virtue of their presence, they create obstructions to the efficient flow of traffic; this inherent ineffectiveness must be reduced (Chakraborty, Gill & Chakraborty, 2016). The presence of mixed traffic conditions in a single toll lane at toll plazas, coupled with the use of manual toll collection (MTC), results in significant congestion and subsequent delays at these locations (Bari et al., 2021). Traffic congestion rises in most regions as travel demand outperforms infrastructural and managerial advancements (Gupta & Kalmanje 2006). The transportation sector generates around one-seventh of global pollution, necessitating reduction efforts (Aktar et al., 2021). To save costs and wait times, electronic toll collection technology is widely used to collect tolls; it automatically connects to toll payers' bank accounts to charge cars by debiting those accounts. The Electronic Toll Collection (ETC) system is now widely adopted across the globe. Countries such as Canada, Poland, Japan, Italy, and Singapore are among the many that have implemented ETC systems, streamlining toll collection processes and improving efficiency in transportation networks (Joshi et al., 2017).

Toll System in India

Toll Tax

The Indian Government levies taxes on every highway in India, whether state or national, to raise money for maintenance. Toll tax is collected to recoup the whole capital outlay, which covers the cost of construction, maintenance, repairs, toll operation charges, and interest on the outlay. Most highway projects in India are awarded based on a public-private partnership. In this scenario, a private company finances and builds the facility and then collects capital from customers in the form of toll taxes. A suitable amount of time is allowed for this tax to be collected before the facility is made accessible to the general public. To reduce traffic congestion and pollution in metropolitan areas, tolls are now being imposed for parking vehicles in high-traffic zones, a concept known as congestion pricing. Furthermore, safety on these highways is crucial due to the high rate of highway robberies in several regions of India. Road tax, in turn, aids in maintaining the expense of maintaining road security and safety. Based on variables including engine power, seating capacity, unladen weight, and cost, the road tax is computed. However, there will be differences in the laws and standards that apply to taxes in each state. Toll roads face criticism for the time required to stop and pay, as well as the operational costs of toll plaza management, which can account for up to one-third of the revenue in some cases. Automated toll collection systems help mitigate both of these issues, improving efficiency and reducing costs.

Types of Toll Collection

Two different kinds of toll collection systems are:

i. Open Toll System

In this system, tolls are not applied to every customer. The toll plaza is generally located at the edge of the urban area, where most long-distance drivers are committed to the facility, with a low possibility of moving to the parallel free route. Customers are categorized, and each category is assigned a specific toll rate. Local traffic around the plaza can use a service lane or receive a rebate.

ii. Closed Toll System

Customers pay the toll in a closed toll system according to their vehicle's type and the distance they travel to the facility. Free rides are not permitted. A closed toll system has plazas at every point of entry and exit, and users are given tickets as they enter the system. When leaving, the customer surrenders the ticket to the collector, who then charges them the appropriate amount based on the type of vehicle and the distance travelled. Unlike an open system, which allows for multiple stops, it only has two stops for automobiles. However, it costs more to build a closed system than an open system.

Methods of Toll Collection

The three different kinds of toll collection in India are,

Manual Toll Collection

In India, the most common toll collection method is manual toll collection. There must be an attendant or toll collector. The cash toll is paid to the collector based on the categorization of the vehicle. In addition to providing change, the collector can receive and sell cash, tickets, and coupons. They also enter the customer's vehicle into the system and give them a receipt. Processing takes the longest due to manual involvement.

Automatic Toll Collection

The usage of Automated Coin Machines (ACM) is the basis of automatic toll collection. These accept operating agency-issued tokens as well as coins. Depending on the toll rate, using automated coin

or token collection as opposed to manual collection cuts down on both operating costs and transaction and processing times.

Electronic Toll Collection System

A vehicle equipped with a properly encoded data tag or transponder is automatically recognised by an Electronic Toll Collection (ETC) system as it passes through a toll lane or checkpoint. Without the user needing to stop and pay the toll, the ETC system subsequently records a debit or charge to the user's account. ETC speeds up traffic, as there is no need to stop and pay the toll (Shahrier & Huq, 2021).

NETC FASTag: Insights into Implementation and Operation

FASTag, an Electronic Toll Collection (ETC) system in India operates and manages by the National Highway Authority of India, through its subsidiary Indian Highway Management Co. Ltd. (IHMCL). The National Payments Corporation of India (NPCI) oversees FASTag transactions within its extensive digital payment framework, facilitating instantaneous toll payments straight from the user's associated bank account or digital wallet. NPCI is a comprehensive entity that manages most retail payment systems in India. In 2014, FASTags were first installed as a demonstration project at the Golden Quadrilateral between Ahmedabad and Mumbai (Joshi et al. 2017). By 2017, 370 toll plazas under NHAI's jurisdiction had a FASTag lane installed. The government mandated the use of FASTag for all new vehicles sold in India that year. Later, the NHAI mandated the use of FASTags beginning on February 15, 2021. FASTag enables direct toll payments on National Highways through Radio Frequency Identification (RFID) technology, which uses radio waves to identify tagged objects linked to prepaid or savings accounts. With a FASTag card affixed to the vehicle's windshield and a scanner positioned at highway toll booths, vehicles can pass through toll plazas without human interaction (The Statesman, 2020). Using RFID technology, the card on the vehicle communicates with the scanner at the toll booth. Once the vehicle reaches the toll plaza, the necessary toll amount is promptly debited from a prepaid wallet or bank account connected to the FASTag. The FASTag owner receives an SMS notification whenever money is deducted from their account or wallet. There is no expiration date for the balance amount on a FASTag; it remains valid as long as the tag is intact and can be read at toll booths. If a vehicle does not have a FASTag or if the tag's balance is insufficient, the driver must pay double the toll amount in cash to pass through the toll booth. Additionally, vehicle owners are liable to pay double the toll even if the FASTag is malfunctioning due to card damage. Waiting times, fuel costs, and vehicle running expenses will be minimized with the aid of FASTag. It will prevent accelerating, idling, and emitting hazardous vehicle emissions. It helps to lessen the congestion, pollution, and usage of paper. Using centralised user accounts avoids cash handling, which improves audit control. It will promote digital payments and enhanced information and data gathering to track traffic and revise the toll policy of government. In comparison to conventional toll collection, FASTag offers numerous benefits to the society, government, general public etc.

FASTags are issued by 37 certified banks via a variety of channels, including point-of-sale (POS) terminals at some bank branches and National Highway toll plazas. They are also offered on mobile wallets like Paytm and e-commerce sites like Amazon. State Bank of India, Axis Bank, HDFC Bank, IDFC Bank, ICICI Bank, Punjab National Bank, Federal Bank, Kotak Mahindra Bank, IndusInd Bank, Syndicate Bank, Yes Bank, Union Bank, etc and payments banks like Fino Payment Bank and PayTm are some of the leading banks in issuing FASTags. The technology was successfully adopted by offering its services through banks. By utilizing technical advancements to upgrade payment systems and develop new payment methods, banks have created strategies and policies to promote growth through innovative electronic payment methods. Electronic technologies that are tailored to the digital economy are being introduced alongside other communication channels as part of a policy to make services more accessible to the client (Walid 2020).

Review of Literature

Electronic Toll Collection (ETC) is an automated system for toll collection that has been widely researched and implemented on highways, bridges, and tunnels worldwide. Through data exchange between RFID tags placed on vehicles and antennas installed along the roadside or on toll gates, the central control computer identifies the road user by the information stored in the tag. It then deducts the toll fee from a prepaid card or linked bank account. The key benefit of ETC is that vehicles can pass without stopping, greatly enhancing toll station efficiency and improving traffic flow on toll roads (Xiao, Guan, & Zheng, 2008). The implementation of the E-toll system has significantly reduced traffic congestion, a growing issue in major metropolitan areas. This system offers an efficient solution for managing heavy traffic by eliminating the need for travelers to wait in long queues at traditional toll booths. Conventional toll payments result in wasted fuel, time, and increased pollution, along with the inconvenience of carrying cash. In contrast, the E-toll system streamlines the payment process, reducing fuel consumption and eliminating the need for cash, offering a more convenient and eco-friendly travel experience (Algonda, Sonar, & Bhutada, 2018). (Chauhan & Chauhan, 2022) analyze the automated toll collection system aimed at deducting toll fees from moving vehicles at toll plazas in

India. The method outlined offers an efficient way to detect and recognize vehicle license plates. A dedicated database was established to evaluate the system's performance, containing details such as vehicle registration numbers, owner names, unique identification numbers, mobile contacts, and linked bank account balances. The findings highlight a significant decrease in vehicle wait times, queue lengths, fuel consumption, and pollution at toll points. In the future, this system could also be adapted for vehicle theft prevention.

Khan, (2019) examines the challenges and potential of introducing ETC in Bangladesh through a questionnaire survey and key informant interviews, with nine participants surveyed. Seventy percent of respondents were aware of ETC's launch, and most believed it would ease traffic jams caused by manual toll payment. However, challenges remain, as this is a new technology. With collective efforts, ETC could align with the vision of Digital Bangladesh and improve toll payment efficiency. In a developing country like Bangladesh, the highway traffic management system requires efficient Electronic Toll Collection (ETC) technologies (Zoy, Shahrier, & Huq, 2020). Aligning with the vision of a "Digital Bangladesh," RFID-based ETC systems offer an affordable and easily implementable short-term solution. However, for long-term benefits, more advanced technologies such as mobile phone tolling and satellite-based Electronic Road Pricing (ERP) may be optimal for both the government and the public. Karsaman et al., (2015) examined three types of Electronic Toll Collection (ETC) systems implemented on various toll roads in Surabaya, Indonesia. Although all systems are based on RFID technology, they differ in work mechanisms and equipment specifications, resulting in varying service performance. Overall, ETC is more cost-effective than traditional toll systems. Interviews with toll road users revealed general satisfaction with ETC, along with expectations for further improvements, such as multi-bank interoperability and the use of cards for multiple merchants or multipurpose applications.

Joshi et al., (2017) compares modern automatic toll collection systems with traditional methods. It examines systems like FASTag, which employs RFID (Radio-Frequency Identification) technology, and BookMyToll, an Android app-based solution that uses smart devices to detect nearby mobile devices at toll plazas. The author emphasizes that manual toll collection can be inefficient, often causing congestion at busy toll booths. To avoid long queues for cash payments, commuters increasingly rely on these electronic systems, allowing for quicker and more convenient transit through toll roads on a daily basis. Ahmed et al., (2019) discusses the RFID-based Electronic Toll Collecting System as a strategy to solve the traffic issue and preserve the transparency of the system. This developed system seeks to develop a computerised toll system that can clear gridlock on toll roads, toll tunnels, and toll bridges without using currency or needing cars to stop. The literature highlights the effectiveness of Electronic Toll Collection (ETC) systems like FASTag in reducing congestion, wait times, fuel consumption, and emissions at toll plazas.

Objectives of the Study

General Objectives

- To gain a comprehensive understanding of advancements in toll collection systems in India, with a focus on the implementation of the NETC FASTag system.

Specific Objectives

- To identify the key factors shaping user perceptions of NETC FASTag.
- To provide actionable recommendations for enhancing the overall FASTag user experience.

Methodology

This research adopts a descriptive and analytical approach. Primary data was collected from 400 FASTag users in Palakkad district, Kerala, using a structured questionnaire to identify the factors influencing their perceptions of NETC FASTag. The study employed a purposive sampling technique, focusing solely on FASTag users to ensure relevance to the research objectives. Krejcie and Morgan's sample size determination table was used to accurately determine the minimum required sample size for the study. It indicated that at least 384 responses were required for an infinite population. A total of 400 reliable responses were gathered and finalized for analysis.

In addition to demographic questions, a five-point Likert scale with 16 statements (both positive and negative) related to user perceptions was used. Percentage analysis was applied in the initial phase, followed by factor analysis using SPSS software to identify the key influencing factors. The questionnaire was pretested with 50 respondents to identify any issues in clarity and accuracy, with adjustments made based on their feedback. Secondary data from newspapers, articles, and online sources were also incorporated to provide context on the toll collection system in India.

Results and Discussions

Table No. 1: Socio-Demographic Profile of Respondents

Sl. No.	Variable	Category	%
1.	Gender	Male	72.5
		Female	27.5
2.	Age	18 – 36 years	48
		37 – 55 years	36
		More than 55 years	16
3.	Occupation	Employee	63
		Business	23
		Profession	12
		Others	2

Source-Computed data, N=400

The demographic profile of the study participants shows a higher representation of male respondents compared to females. In terms of age, the majority of users fall within the younger to middle-aged groups, with fewer participants in the older age category. Most of the respondents are employees, followed by those engaged in business, while a smaller proportion are professionals and others in varied occupations.

Table No. 2 : KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.813
Bartlett's Test of Sphericity	Approx. Chi-Square	4.852E3
	df	120
	Sig.	.000

Source: Computed data

The KMO value indicates whether the variables in the dataset are adequately suited for factor analysis. Values above 0.80 are considered that the data is suitable for factor analysis (Kaiser, 1974). A KMO value of 0.813 suggests that the data is well-suited for factor analysis, as there is enough common variance among variables to justify the use of this technique.

Bartlett's test checks if the correlation matrix is significantly different from an identity matrix (where variables are uncorrelated). A significant result (p-value < 0.05) indicates that the variables are sufficiently correlated (Bartlett, 1950). The p-value is 0.000, which is highly significant. This result confirms that the data is appropriate for factor analysis, as the variables are not independent and have enough correlations.

Table No. 3: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	
1	4.543	28.394	28.394	4.543	28.394	28.394	4.478	27.986	
2	3.183	19.894	48.288	3.183	19.894	48.288	3.210	20.061	
3	2.776	17.351	65.639	2.776	17.351	65.639	2.686	16.787	
4	2.245	14.033	79.671	2.245	14.033	79.671	2.374	14.839	
5	.484	3.025	82.697						
6	.419	2.621	85.318						
7	.365	2.279	87.597						
8	.347	2.168	89.765						
9	.338	2.115	91.880						
10	.286	1.786	93.666						
11	.232	1.448	95.114						
12	.217	1.359	96.473						
13	.171	1.071	97.544						
14	.139	.868	98.412						
15	.133	.830	99.242						
16	.121	.758	100.000						

Extraction Method: Principal Component Analysis.

Source: Computed data

The first four factors have eigenvalues greater than 1, indicating they are significant contributors to the variance. The cumulative variance of 79.67% by these four factors signifies that together they explain a

significant amount of variability in user perceptions. After extraction, the values in this instance remain the same because all components with eigenvalues greater than 1 were retained. The extraction method used here is Principal Component Analysis (PCA), which retains the most significant factors. After applying rotation, the variance explained by the individual factors is redistributed more evenly. The first factor explains 27.99%, the second explains 20.06%, the third explains 16.79%, and the fourth explains 14.84%. These four factors explain 79.67% of the total variance in the data, which is quite high. This indicates that the underlying structure of the data can be effectively captured by these four factors.

Table No. 4: Rotated Component Matrix

Sl. No.	Statements	Component			
		1	2	3	4
1.	FASTag has improved the efficiency of toll payments at plazas	.828	-.047	-.011	.042
2.	I find the process of recharging my FASTag account easy and convenient	.003	.025	.944	.058
3.	FASTag has significantly reduced the time I spend waiting at toll plazas	.867	-.019	.034	-.042
4.	The toll transaction notifications from FASTag are timely and accurate	.010	-.039	.950	.027
5.	Using FASTag helps me save money by reducing fuel consumption due to shorter wait times at toll plazas	-.026	-.061	.049	.899
6.	FASTag has made road travel more convenient compared to traditional cash payments	.868	.010	.047	-.006
7.	FASTags are often blacklisted automatically due to low balance without sufficient warning or notification, which causes difficulties at toll plazas	-.034	.920	.007	-.019
8.	There is a risk of the FASTag being lost, misplaced, or physically damaged	-.061	.894	-.007	-.025
9.	I have often experienced incorrect or double deductions from my FASTag account	-.043	.862	-.028	-.035
10.	I frequently face issues with my FASTag not being scanned properly at toll plazas	.009	.898	.031	.018
11.	I am satisfied with the customer service provided for resolving FASTag-related issues	.049	.016	.935	.023
12.	FASTag has reduced the need for carrying cash while traveling on highways	.929	-.019	.035	-.014
13.	The FASTag system is reliable for seamless toll payments	.814	-.056	-.047	-.089
14.	I find FASTag to be a cost-effective solution compared to traditional toll payment methods	-.048	.028	-.012	.881
15.	FASTag provides good value by streamlining toll payments and cutting unnecessary costs	-.008	-.023	.065	.878
16.	The FASTag system has reduced traffic congestion at toll plazas during peak hours	.865	-.028	.030	-.006

Source: Computed data

Factor loadings represent the correlation of each variable with a factor. After rotation, the matrix clarifies the relationships, grouping similar variables. Factor loadings above 0.6 are considered high, and variables with high loadings on a particular factor are closely associated with that factor. Principal Component Analysis under the rotation method (Varimax with Kaiser Normalization), rotation converged in 4 iterations. The following four components may be extracted:

Component 1: (Statements 1, 3, 6, 12, 13, 16) All of these items relate to the efficiency of the FASTag system in reducing toll processing time, improving the convenience of travel, and congestion, and its reliability. “FASTag has improved the efficiency of toll payments at plazas” and “FASTag has made road travel more convenient compared to traditional cash payments” highlight that users feel the system streamlines toll payments. “The FASTag system is reliable for seamless toll payments”, indicate users trust the technology for consistent performance. The mention of reducing traffic congestion during peak hours signifies a broader impact on travel efficiency.

Component 2: (Statements 7, 8, 9, 10) This represents challenges users face with FASTag, such as blacklisting without warnings, risk of loss, scanning errors, and incorrect deductions. The high loading of the statement

regarding FASTag being blacklisted indicates a significant problem faced by users, suggesting that technological reliability is a concern. Statements about loss of tag, scanning errors, along with the incorrect or double deductions, further illustrate the issues affecting user satisfaction and trust in the system. The automatic blacklisting due to low balance without adequate notification points to a significant pain point, which could lead to user frustration and dissatisfaction.

Component 3: (Statements 2, 4, 11) The statements about timely transaction notification and finding the process of recharging easy reflects the importance of user-friendly features in service adoption. Satisfaction with customer service for resolving issues points to the significance of support in enhancing the overall user experience.

Component 4: (Statements 5, 14, 15) The statement regarding savings on fuel consumption due to reduced wait times at toll plazas illustrates a direct financial advantage that users associate with using FASTag. The perception of FASTag as a cost-effective solution reinforces the idea that users see tangible financial benefits from using the system, particularly in comparison to traditional toll payment methods. Statements about providing good value by streamlining payments indicate that users appreciate the efficiency and convenience of the service, which translates into cost savings.

The rotated component matrix suggests the presence of the four interrelated factors.

Table 5: Naming of Factors

Factor No.	Name of Dimension	Item No.	Variables	Factor loading
F1	Efficiency	1	FASTag has improved the efficiency of toll payments at plazas	.828
		3	FASTag has significantly reduced the time I spend waiting at toll plazas	.867
		6	FASTag has made road travel more convenient compared to traditional cash payments	.868
		12	FASTag has reduced the need for carrying cash while traveling on highways	.929
		13	The FASTag system is reliable for seamless toll payments	.814
		16	The FASTag system has reduced traffic congestion at toll plazas during peak hours	.865
F2	User Challenges	7	FASTags are often blacklisted automatically due to low balance without sufficient warning or notification, which causes difficulties at toll plazas	.920
		8	There is a risk of the FASTag being lost, misplaced, or physically damaged	.894
		9	I have often experienced incorrect or double deductions from my FASTag account	.862
		10	I frequently face issues with my FASTag not being scanned properly at toll plazas	.898
F3	Service Accessibility	2	I find the process of recharging my FASTag account easy and convenient	.944
		4	The toll transaction notifications from FASTag are timely and accurate	.950
		11	I am satisfied with the customer service provided for resolving FASTag-related issues	.935
F4	Cost-effectiveness	5	Using FASTag helps me save money by reducing fuel consumption due to shorter wait times at toll plazas	.899
		14	I find FASTag to be a cost-effective solution compared to traditional toll payment methods	.881
		15	FASTag provides good value by streamlining toll payments and cutting unnecessary costs	.878

This table provides the names assigned to the factors based on the patterns of the loadings from the rotated component matrix:

Factor 1: Efficiency – This factor highlights the positive perception of FASTag’s efficiency and the convenience it brings to road travel. This factor consistently has high loadings across multiple items, making it the most significant influence on users’ perceptions. Users highly value the efficiency, time-saving benefits, and

convenience FASTag brings to their travel experience. The convenience of quick toll payments not only saves time but also enhances the overall travel experience, making it a game-changer for road users.

Factor 2: User Challenges – This factor captures the negative experiences users have with technical issues, suggesting areas for improvement. The technical difficulties experienced with FASTag, such as blacklisting and the risk of loss of tag, are a major concern for users. This factor holds the second-highest influence on perception, with multiple items having high loadings. Continuous improvement in technology and user interface can help mitigate these negative experiences, reinforcing the positive aspects of efficiency.

Factor 3: Service Accessibility – This factor highlights the accessibility, ease, and satisfaction users experience with FASTag services, particularly in areas like recharging, transaction notification, and customer service. It plays a significant role in shaping user perceptions, with notably high loadings, highlighting the importance of these accessible features in enhancing the overall user experience. This factor is crucial for maintaining user satisfaction, as it ensures that the advantages of efficiency are accessible to all users. By enhancing the support infrastructure, FASTag can further solidify its position in the market.

Factor 4: Cost-effectiveness – This focuses on the financial gains users derive from FASTag, including fuel savings and the overall perception that it is a more economical and valuable toll payment solution compared to traditional methods. While important, it ranks fourth in terms of overall significance based on the factor loadings. By highlighting the savings from fuel efficiency and the comparative value of using FASTag over traditional methods, marketing strategies can effectively communicate the long-term benefits to potential users.

In summary, while efficiency is the primary driver of positive perceptions of FASTag, addressing challenges and enhancing service accessibility will further solidify its position in users' minds. Additionally, emphasizing cost-effectiveness can attract a broader audience, making FASTag a preferred choice in toll payment solutions. Future studies could investigate how these factors influence each other and change over time, which could lead to new ways to make the user experience better.

Conclusion

The study examines technological advancements in India's toll collection system. India, recognized as the world's second-fastest-growing digital economy by McKinsey, has integrated e-services into toll collection. The shift from manual toll collection to automated systems has significantly improved the efficiency of toll management operations. FASTag is one of the most revolutionary electronic toll collection initiatives, as it uses technology for optimizing the payment procedure instead of the conventional manual toll collection practices, which are often slow and prone to human error. The benefits in terms of time-saving and convenience, coupled with its significant advantages, are the most salient feature impacting user perceptions positively. The users consider the reduction in waiting time at toll plazas as an improvement in the overall travel experience and indicate a broader shift toward digitalization in transportation services.

Although FASTag offers many significant benefits, the study also underlines the problems that the user faces, especially the technological challenges. Those challenges, including blacklisting issues, loss of tag as well as scanning errors, represent areas where focus and improvement are needed. Improvement of these technological deficits is required to increase the satisfaction level of users and build trust in the system. An improved, efficient FASTag experience has the ability to significantly raise user satisfaction and increase acceptance among the drivers. Besides efficiency and technical reliability, the research underlines the significance of service accessibility. Factors such as easy recharge of FASTag accounts and responsive customer support would be part of the users' experience. A seamless and user-friendly recharge process and efficient customer service that quickly responds to user inquiries and concerns can significantly influence user satisfaction. These factors of service accessibility enhance the overall user experience and promote increased acceptance of the FASTag system. The research also highlights the economic benefits of using FASTag, particularly in terms of fuel savings and cost-effective solution compared to traditional toll payment methods.

Banks have played a crucial role in the success of FASTag, offering comprehensive services and contributing significantly to toll collection efficiency, a role that continues to expand with emerging technologies. India's road infrastructure is undergoing a remarkable transformation, driven by advanced innovations such as FASTag, Automatic Number Plate Recognition (ANPR), and the recently launched Global Navigation Satellite System (GNSS)-based tolling system. These advancements are revolutionizing toll collection and road maintenance, showcasing India's rapid strides in technological progress (Ajith Athrady, 2022; The Economic Times, 2022; Shubham Chhabra, 2024). The introduction of GNSS with the help of the National Highways Authority of India (NHAI) and the National Payments Corporation of India (NPCI) represents a major milestone in modernizing India's road infrastructure, offering the potential for more efficient toll collection and an enhanced travel experience for millions of road users.

Limitations of the Study

The study is limited by its geographic focus, since it has been restricted to the Palakkad district, and this might impact the generalizability of the results to other areas. Further, there might be bias in the data, since participants might have had varied experiences with FASTag, which could affect the results. Data collection was indeed difficult, especially since the study population was those who use FASTag frequently; less frequent users of the service rarely agreed to participate in the survey. These factors may limit the depth of insights gathered and could influence the overall conclusions drawn from the research.

Implications for Future Developments

Implementing FASTag is an important step forward in terms of India's toll collection systems, aligning with the country's broader goals of digital transformation and efficiency in public services. The findings of the study indicate that stakeholders should focus on error resolution processes and give timely alerts or warnings to avoid blacklisting, thereby reducing user frustration. Simplifying the recharge process and enhancing customer support services to make it more user-friendly. Highlighting the savings in terms of time and fuel for using FASTag and, thereby, a larger user base. By covering these areas, stakeholders can enhance user satisfaction and promote the continued growth and acceptance of digital payment systems in India's transportation infrastructure, paving the way for a more efficient and user-centric toll collection experience.

Future Scope of the Study

The future scope of the study includes several areas for further research. Longitudinal studies could determine how users perceive FASTag over a period of time. Generalizing the geographic focus of the study beyond Palakkad district would help understand different regions' user experiences. Further study into upcoming technologies in road toll collection may establish innovative solutions with regards to improving user convenience and system efficiency. Analyzing demographic factors, such as age and tech-savviness, could reveal differences in user experiences and preferences. Future research could also explore the integration of FASTag with other transportation technologies, as well as conduct comparative analyses with other digital payment systems to identify best practices. In addition, environmental benefits of FASTag can be added to further discussions on sustainability in transportation.

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