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Transfer, Diffusion and Adoption of Next-Generation Digital Technologies

IFIP WG 8.6 International Working Conference on Transfer and Diffusion of IT, TDIT 2023
Nagpur, India, December 15–16, 2023
Proceedings, Part I

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Preface

A new generation of digital technologies are rapidly proliferating at individual, organizational and societal levels. Most of these next-generation digital technologies have strong inter-connections enabling the production, processing and storage of large amounts of data, creation of new data and data-driven decision making. These technologies invite new assessments and research questions to ensure the delivery of maximum value (tangible and intangible both) at an individual, organizational and societal level while avoiding potential harm and negative unintended consequences on individuals, organizations and society at large.

The IFIP WG8.6 group aims "to foster understanding and improve research in practice, methods, and techniques in the transfer and diffusion of information technology within systems that are developed, and in the development process"[1]. In continuing this mission, we organised the IFIP WG 8.6 Conference on "Transfer, Diffusion and Adoption of Next-Generation Digital Technologies" at Indian Institute of Management Nagpur, India on 15–16 December 2023 as a forum for scholars and practitioners to present their research ideas and findings.

The focus of the conference was on understanding the transfer, diffusion and adoption of next-generation digital technologies and systems e.g., metaverse and augmented/virtual reality, blockchain, fintech, artificial intelligence, conversational AI, LLMs, ChatGPT, internet of things and social media among other prominent digital technologies that are expected to have a significant impact on the future economic development of societies, organizations and individuals. The strong link between technology adoption and socio-economic development in many economies is evident from a review of the role of information technologies, particularly over the last two decades. Recently in Forbes, a popular contributor, Bernard Marr, wrote in 2023 "What we're starting to see with metaverse is that we're ready for a new chapter of the world wide web – a new chapter of the internet … think of it perhaps as an immersive Internet". These above-mentioned next-generation digital technologies have a great potential to contribute to the reformation of organizations and societies and their unintended consequences are yet to surface. In recent years, scholars have shown great interest in understanding how these technologies are introduced, how they are used, and what their effects and potential are on people, societies and businesses.

This conference brought together scholars and practitioners from interdisciplinary fields in order to enrich scholarly reflection on the adoption, use, impact and potential of next-generation digital technologies. The conference mainly focused on papers that addressed questions related to the diffusion and adoption of emerging technologies. Besides, we were also open and committed to the broader theme of IFIP Working Group 8.6. We received 209 papers from academicians and practitioners worldwide. All submissions were double-blind reviewed by at least two reviewers. The reviewing

[1] http://ifipwg86.wikidot.com/about-us.

process resulted in the acceptance of 89 full papers and 23 short papers to present in the conference. The acceptance rate of submitted papers was about 54%. We are grateful to all track chairs who selected reviewers and the large team of reviewers who provided constructive and timely feedback to authors.

We sincerely thank all authors, reviewers, participants, program committee members, track chairs, advisory board, IFIP WG8.6 officials and IIM Nagpur faculty & staff who helped in making this conference a grand success.

December 2023

Sujeet K. Sharma
Yogesh K. Dwivedi
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Digital Technologies (Artificial Intelligence) Adoption

How Financial Inclusion Can Contribute to Social Inclusion? A Conceptual Framework from the Perspective of Digital Technologies

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Abstract. The purpose of this paper is to develop a conceptual framework for the relationship between technological drivers in Financial Inclusion and components of Social Inclusion. Additionally, the paper also draws a conceptual framework highlighting the association between Financial Inclusion and Social Inclusion incorporating digital technology as a catalyst from the literature available. There has been a positive relationship observed between the technological factors in Financial Inclusion and determinants of Social Inclusion.

Keywords: Financial Inclusion · Social Inclusion · Digital Technologies

1 Introduction

Policymakers in advanced economies have expressed their commitment to advancing both financial inclusion and social inclusion, which are development goals intended to improve the overall socioeconomic welfare of all members of society [9, 35]. This reflects the recognition of the importance of ensuring equal access and opportunities for individuals across various socioeconomic aspects [3, 27, 39]. In some countries, the focus on other pressing economic needs has prevented them from prioritizing social and financial inclusion as a major policy objective. According to studies conducted, factors contributing to Financial Inclusion are credit services, ATMs, branch penetration, credit penetration, deposit penetration, borrowing rates, peer to peer lending, Financial literacy, income, and so on [33]. On the other side use of financial technology (fintech) also plays an important role in expanding the accessibility of financial services to diverse segments of society. The adoption of digital technology is a crucial determinant of financial service usage [14]. Extensive literature demonstrates how financial inclusion facilitated by digital technology has contributed to economic development.

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The utilization of digital technology is commonly recognized as a means to promote social inclusion by facilitating the availability of immediate services. It empowers individuals to engage in various activities such as learning, working, traveling, socializing, shopping, and participating in community interactions, regardless of physical constraints. Digital technologies including communication device, cellular phones, internet penetration, computer, software, satellite systems have facilitated in rapid growth in financial transactions which leads to financial inclusion [18]. Digital technologies attempt to facilitate both, Financial Inclusion as well as Digital Inclusion. Given the catalytic role of digital technologies in connecting social inclusion and financial inclusion, it is vital to establish the relationship between the factors that contribute to each. Thus, it becomes imperative to develop a conceptual framework that highlights the interconnectedness of these two crucial aspects of society.

2 Literature Review

2.1 Social Inclusion

Social inclusion entails ensuring equal chances for all members of society to approach resources and participate fully [32, 36, 48]. Policies and institutions focused on social inclusion aim to remove barriers that hinder individuals from meaningful engagement, enabling their complete involvement in society [11, 30, 42]. Social inclusion indicators have been recognized in policy and academic literature, including gender equality, fair allocation of resources, development of human resources, social protection, combating discrimination, environmental sustainability, and leveraging social technology [17, 26].

In the realm of social policy, gender equality, environmental sustainability, and social protection have gained prominence as significant indicators of social inclusion in recent years [4]. Ozili (2019) highlights their increasing importance in social activism. But it's crucial to understand that the prominence of these indicators does not compulsorily make them the most comprehensive measures of social inclusion. They may be subject to criticism for their limited focus compared to broader indicators such as equal voting opportunities [6], development of social skills [50], utilization of social technology [17, 22], provision of recreational spaces [12], and participation in the social economy [34]. The dimensions of social inclusion encompass various areas, including quality education, innovation and technology, governmental policies and laws, poverty and the economy, healthcare, and community and culture [21].

2.2 Financial Inclusion

The process of assuring that everyone has admission to fundamental financial services within the established financial sector is known as financial inclusion [39]. It involves providing individuals with the ability to utilize credit products, money transfers, and savings facilities, thereby fostering their engagement in the financial system. A well-developed and accessible inclusive financial system can create new business opportunities in the private sector, leading to positive economic impacts. Additionally, such a system enables the efficient distribution of financial resources, contributing to overcoming challenges

like poverty and promoting growth and stability. Enhancing access to financial services facilitates access to additional resources, further stimulating economic development [2]. Financial inclusion is widely acknowledged as a driver of economic and social progress, with the World Bank emphasizing its role in reducing poverty and promoting shared prosperity [49].

Advocates of financial inclusion contend that it has the capacity to boost the welfare of individuals with limited incomes and those living in poverty, particularly in developing nations [3, 9, 39]. Numerous factors can impede financial inclusion, including technological constraints [5], high costs associated with opening accounts [3], significant transaction expenses in financial intermediation [39], the politicization of national strategies for financial inclusion [44], and voluntary exclusion from financial services [39]. Conversely, certain factors can facilitate financial inclusion, such as proximity to microfinance institutions [7], educational attainment, income, and age [51], financial literacy [20, 37, 40, 41], financial innovations [47, 56], institutional regulations [8], and regulatory support for the growth and development of social enterprises [54].

2.3 Financial Inclusion

Policies aimed at fostering financial inclusion have the potential to promote social inclusion as well. Through measures like providing micro-credit as a social policy to alleviate poverty, expanding access to credit for households, and embracing financial innovations such as digital finance and cryptocurrencies, financial inclusion can enhance the availability of financial services for all individuals in society [10, 25]. Conversely, social inclusion policies can support financial inclusion by creating social enterprises or institutions that advocate for gender equality, anti-discrimination measures, and environmental sustainability. This ensures that social biases, gender disparities, or discrimination do not hinder access to financial products and services for individuals with low incomes and those in poverty [40]. The concepts of financial inclusion (and exclusion) and social inclusion (and exclusion) exhibit significant overlap. From a sociological outlook, societies characterized by high levels of social inclusion foster trust among their members, thereby instilling trust in financial institutions and their services. Thus, societal trust plays a crucial role in the positive relationship between social inclusion and financial inclusion. Moreover, the financialization of economies and societies may also contribute to this correlation [41].

Developing countries often promote social inclusion through financial inclusion policies and initiatives focused on digital finance, including the expansion of mobile phone usage, the adoption of digital banking applications, and the emergence of fintech. These endeavors receive support from various stakeholders, including non-governmental organizations, governments, and profit-oriented multinational financial institutions [40].

The growth of digital platforms and the digital economy has raised concerns regarding gender discrimination, highlighting the importance of institutions and policies in addressing this issue. The implications of the digital sharing economy for shaping social norms and promoting sustainable development require attention, with institutions and policies playing a crucial role in driving progress [45]. The policies and institutions formed to foster social inclusion can complement and encourage initiatives aimed at promoting financial inclusion [40].

From the above literature relationship between Financial Inclusion and Social Inclusion can be drawn by incorporating digital technology as catalyst (Fig. 1).

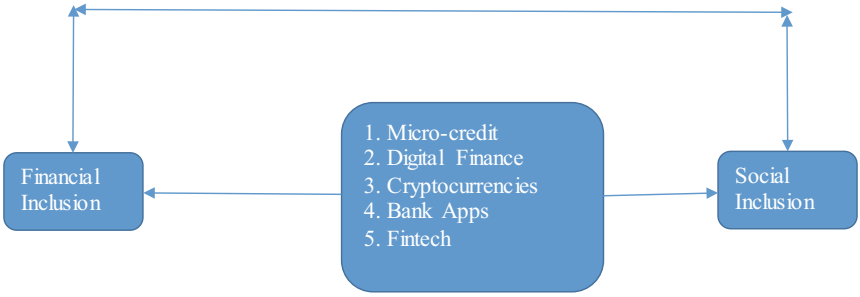

Fig. 1. Relationship between Financial Inclusion and Social Inclusion by incorporating digital technology as catalyst (Author's design)

2.4 Digital Technologies and Finance

Payment systems serve as the foundational financial service and are often referred to as "the connective tissue of a financial system" [43]. The emergence of digital payment technologies, in conjunction with the widespread usage of mobile phone technology, enables the transformation and restructuring of financial systems. This includes the utilization of prepaid cards, mobile financial apps, and mobile banking, among other innovations. Digital financial services are extensively utilized, encompassing various aspects such as digital transactions, payment platforms, retail agents, and customers using mobile phones or other devices to conduct transactions on digital platforms [28]. Radcliffe and Voorhies illustrate the interconnected infrastructure elements of digital financial platforms that relate diverse groups of people with a wide scope of services essential for their daily lives, including utilities, government services, and social services. Digital financial services encompass multiple financial platforms, products, and businesses, involving interactions with FinTech companies and financial service providers [19].

Achieving universal financial inclusion is significantly facilitated by the expansion of global mobile access. The increasing affordability and accessibility of advanced mobile technologies have led to the development and implementation of innovative mobile-based financial services. The widespread use of mobile devices has played a crucial role in accelerating global mobile inclusion, contributing to the expansion of digital financial services in both developed and developing countries (Fig. 2). Utilizing digital technology, especially the internet, has proven to be an effective method of reaching a wide customer base across vast geographical regions. It has been observed that there is a definite correlation among internet usage and the level of financial inclusion, which further facilitates the adoption of digital financial products like internet banking, peer-to-peer lending, and crowdfunding [52]. In India, there has been a significant increase in mobile phone subscriptions from 2017 to 2022, and further growth is expected until 2027, indicating an upward trend in technology utilization (Fig. 3).

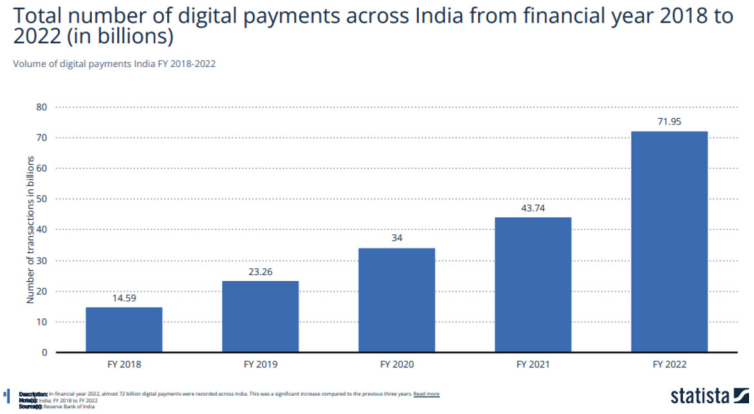

Fig. 2. Number of Digital Payments across India Source: Statista

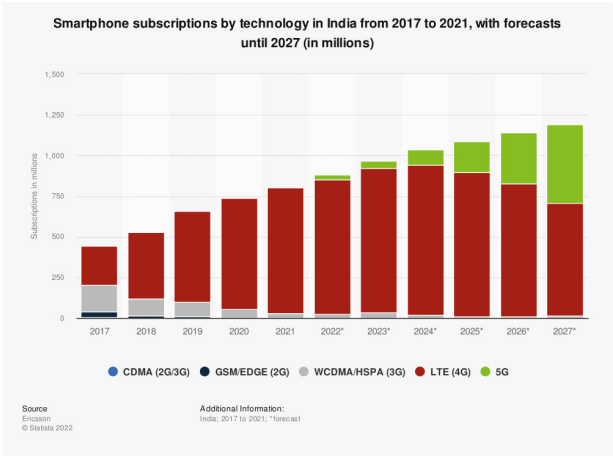

Fig. 3. Number of Digital Payments across India Source: Statista

The successful implementation of financial inclusion in a country relies heavily on two main pillars: banking services and technology. By leveraging the most recent technological advancements such as e-KYC, IMPS, AEPS, and mobile banking, banking facilities can be made accessible throughout the entire country. These technological innovations have the potential to revolutionize the financial landscape by reducing costs, enhancing convenience, and improving the speed of service delivery. The acceptance towards Core Banking Solutions (CBS) by banks has facilitated the introduction of various products like NEFT, RTGS, mobile banking, internet banking, ATMs, and more. Technology plays a crucial role in enabling banks to provide services to a larger section of society, particularly focusing on underprivileged communities. The effectiveness of financial inclusion relies on the capacity to extend banking services to the unbanked population and effectively employ cost-efficient technology to transform the financial

ecosystem in India. The USSD platform offers a mobile-friendly solution that eliminates the need for application downloads. USSD is user-friendly, facilitates effective communication, and enables customer education [49] (Fig. 4).

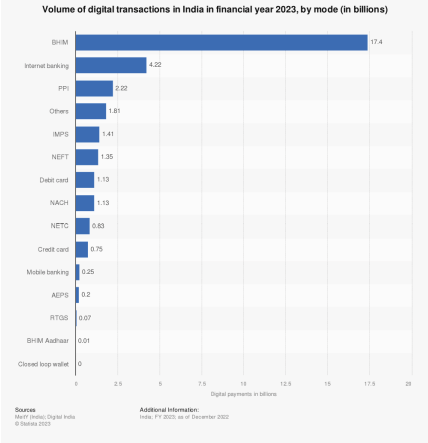

Fig. 4. Number of Digital Payments across India Source: Statista

2.5 Technology and Social Inclusion

When digital finance is employed to the lives of individuals with low incomes and those in poverty, it has the potential to enhance their access to essential services, leading to increased financial inclusion in rural areas. By directing digital financial services to rural and impoverished communities, access to finance can be improved for customers who face challenges in conveniently reaching banks located in the formal sector [39]. Recent research also indicates that modern information and communication technologies (ICTs) can serve as effective tools for promoting the social inclusion of refugees, improving their well-being, and empowering them to take charge of their lives. Immigrants utilize various applications such as communication tools, language learning and translation platforms, information access, and knowledge expansion [1]. Studies also reveal that there is an increase in the use of mobile technology for communication with acquaintances, and colleagues, and for reading e-books which gives a sense of social inclusion to the general population [31]. Reliance on social networking technology and media technology can increase social inclusion [55]. A higher level of digital engagement like the use of mobile phones, and internet technology can ease social inclusion [18].

2.6 Studies Conducted in Terms of Social Inclusion

Areas that have been studied so far in social inclusion from the technology point of view have used various terms to describe technology as an enabler of social inclusion. Various technological terms are utilized in the articles, including communication technology, adaptive technology, assistive technology, instructional technology, web technology, telerehabilitation technology, internet-based technology, mobile technology, speech recognition technology, virtual technology, electronic technology, GPS technology, screen reader technology, game technology, and voice recognition technology, among others [29]. Amidst the COVID-19 pandemic, these technologies played a crucial role in enabling caregivers to fulfill vital aspects of their social inclusion and support provision. They facilitated social connectivity, fostered a sense of solidarity, providing access to resources and information, facilitated engagement in social and cultural activities, and promoted independence in their caregiving responsibilities [23].

In a study conducted by Ragnedda, Ruiu, and Addedo in 2022, the findings revealed the diverse ways in which individuals utilize the internet to enhance their social inclusion, such as strengthening existing offline social relationships, procuring essential goods, and staying updated on current affairs.

3 Conceptual Model: Relationship Between Financial Inclusion and Social Inclusion Incorporating Digital Technology as a Catalyst

This section proposes the conceptual framework, articulating the critical link between technological drivers in Financial Inclusion and dimensions of Social Inclusion. We developed a conceptual framework from the literature available to understand how different digital technologies in financial inclusion can positively impact Social Inclusion drivers (Fig. 5). Digital Technologies benefiting Financial Inclusion are Digital Transactions, Mobile Apps, Mobile Banking, Prepaid cards, Fintech, Internet Banking, Peer to Peer Funding, Crowdfunding, e KYC, IMPS, NEFT, RTGS, UPI Payment, and so on [14, 28, 49, 52]. Innovation Fintech has facilitated Crowdfunding, Peer to peer business and cryptocurrencies [13]. Mobile banking services available are funds transfer through RTGS, NEFT and IMPS, balance enquiry, request services demat account services and so on. In the backdrop of the literature available, it can be observed that these factors are also benefiting social inclusion by increasing the scope for the population in rural areas and population below the poverty line to provide them access.

Dimensions that contribute to Social Inclusion are Gender Equality, Environmental Sustainability, Social Protection, Innovation and Technology, Poverty and Economy, Quality Education, Healthcare, Community, and Culture. These components of social inclusion get strengthened with the expansion of digital technology. Thus, a positive relationship can be drawn between technological factors in financial inclusion and social inclusion dimensions. The conclusion can be drawn that the promotion of Financial Inclusion through digital technologies will automatically lead to social inclusion.

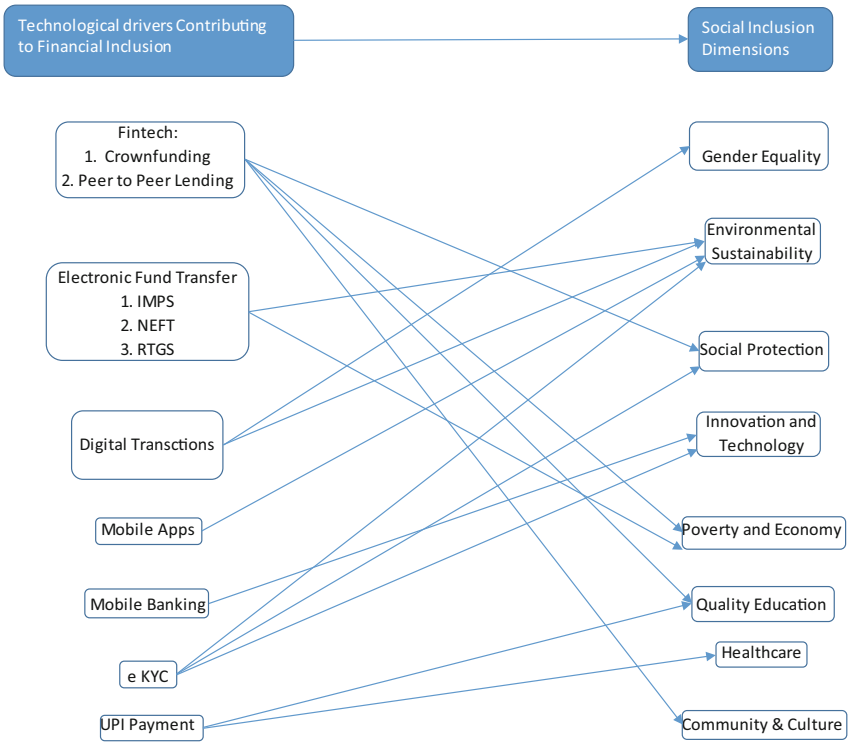

Fig. 5. Conceptual Model deriving the relationship between technological factors contributing to Financial Inclusion and dimensions of Social Inclusion (Author's design)

4 Conclusion

The core purpose of this study is to develop a link between two major initiatives by Government, Financial Inclusion and Social Inclusion. There are varied technological initiatives in digital finance that lead to Financial Inclusion. From the previous studies conducted, it can be contemplated that there is an association between technological drivers in Financial Inclusion and dimensions of Social Inclusion. Both variables seem to be interconnected. Digital finance initiatives like micro-finance, cryptocurrencies, bank apps, and fintech are contributors towards both initiatives (Financial Inclusion as well as Social Inclusion).

When policymakers work towards advancing financial inclusion, they should consider the impact of social inclusion policies and programs on the extent of financial inclusion in their countries. Recognizing the inherent trade-off between social inclusion and financial inclusion is crucial for policymakers as they develop effective policies in both domains. By comprehending the connection between financial and social inclusion, policymakers can ascertain the appropriate level of social inclusion that encourages financial inclusion optimally. Furthermore, policymakers must closely monitor the achievement of financial inclusion policies to prevent unexpected social consequences that could lead to social exclusion.

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The European Union's Artificial Intelligence Act: An Analysis of Preliminary Perceptions and Responses of Irish SMEs

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Abstract. EU is preparing to introduce the AU AI Act, hopefully by end of 2023. This is causing a great amount of anxiety among a variety of industries. In this study, we look at the EU-AI Act and its impact on Irish small and medium enterprises (SMEs) to analyze what would be the perception of the act as well as the pain points of the SMEs in adapting to this act. We use qualitative methods and semi-structured interviews to identify themes and patters in our study. We find the general lack of trust in government's support and heavy regulatory requirement from resource constrained SMEs are the primary factors that are causing concerns in this sector.

Keywords: Artificial intelligence · European Union · semi-structured interviews · technology adaptation

1 Introduction

In recent years, there has been a significant surge in AI capabilities [1, 2], prompting the European Union (EU) to initiate the introduction of regulations to govern the use of AI technologies within its market [3], named the European Union's Artificial Inelegance Act (EU-AI Act). The EU-AI Act has been purposefully designed with broad definitions of AI to mitigate the potential for technologies to fall outside its regulatory scope. Due to this broad approach, legislators incorporated a sliding risk scale, aligning regulatory requirements with varying levels of risk [4, 5]. By implementing this scalable framework, the legislation aims to effectively address and regulate AI applications based on their associated risk levels.

There are concerns regarding the potential for small and medium enterprises (SMEs) operating within the EU to experience a disproportionate impact due to introduction of the EU-AI Act. SMEs are defined as organisations employing fewer than 250 individuals, turnover of less than €50 million, or a balance sheet of less than €43 million [6]. Should these concerns materialise, the effectiveness of the Irish government's AI strategy could be jeopardised. In 2021, the Irish government released its AI strategy titled "*AI - Here for Good: National Artificial Intelligence Strategy for Ireland*". This strategy emphasises

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that widespread adoption of AI technologies across enterprises of various sizes, including SMEs, is crucial for maximizing the economic benefits of AI and enhancing productivity [7, 8]. This underscores the significant role SMEs play in realising the strategic objectives outlined in the Irish government's AI strategy.

As this legislation is relatively recent, there exists a gap in the current research concerning its potential implications for Irish based SMEs. Addressing this research gap can help in developing an understanding of the potential challenges and opportunities that the EU-AI Act may present for SMEs in Ireland. This research aims to bridge this knowledge gap by exploring the perceptions of Irish SMEs regarding the forthcoming EU-AI Act. Its primary objective is to assess the potential impact of the legislation on SME operations and, analyse the consequential implications for the Irish government's AI strategy.

2 Background and Literature Review

2.1 Artificial Intelligence

The concept of artificial intelligence (AI) was first introduced in 1956 by John McCarthy, Marin Minsky, Claude Shannon, and Nate Rochester [9]. Today, there lacks and agreed definition [10], however AI is commonly described as human-like intelligence, demonstrated by machines [11, 12]. The potential for AI to benefit businesses and society has been rapidly advancing and expanding in recent years. Over the decades since its introduction, the term AI has evolved into an umbrella term encompassing a range of computational capabilities which include machine learning (ML), natural language processing (NLP), computer vision, optimisation, and automated planning and scheduling [13, 14]. This varied definition and broad range of technologies incorporated under the AI umbrella shows the AI and its technologies are highly complex.

When AI is discussed there are two categories that are mainly spoken of, narrow and general AI. Until recently most progress in AI advancements have been cases of narrow AI, where the model has been trained to perform a single task, similar to Google's alpha go model which was trained to out compete the world champion of the highly complex, ancient Chinese strategy game of Go [9]. However recently there have been substantial developments in the field of AI which indicate an approach to general AI [15, 16], where the model is trained using an extensive data set to perform a variety of tasks, similar to the case Open AI's GPT-4 model. GPT-4 is an multi modal AI system that can operate with multiple mediums of inputs and outputs. Furthermore, it has been shown to achieve results that are comparable to those of a human on several academic and professional benchmarks [17]. This development of AI's increased capabilities shows that the field is moving from a predominantly narrow AI basses to a hybrid mix of narrow and general AI. With this shifting baseline of capabilities will come a greater need for oversight.

As the capabilities of AI continue to develop, so do both the positive and negative consequences associated with these systems. According to Mikalef & Gupta [18] the impact of AI on society will be transformational. This transformation will bring benefits through improved products, processes and decision-making capabilities [19]. Furthermore, AI has been shown to benefit public health, the environment, drive scientific breakthroughs [20] and increase GDP [7]. These positive aspects of AI provide

promise for society as a whole [21]. The potential for AI to bring transformative change to society is clear and as a result, positive innovation in the field should be encouraged and celebrated.

It is widely agreed that users need to have trust is AI [1, 22]. Looking at the digital disruptions brought about by social media and e-marketplaces, the presence of trust and distrust led to greater oversight of the technologies [23]. Transferring this to the field of AI it can be said that the trust requirements of the system show a need for sufficient oversight through governance practices. AI governance will be required to manage the associated risks of AI and ensure society reaps the benefit of the technologies [24]. This ought to be achieved through operating AI in line with social and human values [25, 26] and meeting ethical concerns [27, 28]. This shows the importance of aligning with humane values in building trust in AI systems.

2.2 EU-AI Act

Due to the complexity of AI, its governance will be equally as complex. Examining the current state of the practice, it can be seen that the area of AI governance is unorganised [27]. This unorganised state may stem from the challenges that are faced when implementing AI governance as AI governance requires the implementation of abstract ethical frameworks, an area where developers may lack sufficient expertise to implement policies [29, 30]. Mäntymäki describes AI governance as "a system of rules, practices, processes, and technological tools that are employed to ensure an organization's use of AI technologies aligns with the organisation's strategies, objectives, and values; fulfils legal requirements; and meets principles of ethical AI followed by the organisation." [24]. This description is of interest as it highlights the legal aspect of governance. The legal space around AI governance has historically been fragmented. Noticing the shortcomings, the president of the Europe Commission, Ursula von der Leyen, made the regulation of AI a top priority for her term in office: "In my first 100 days in office, I will put forward legislation for a coordinated European approach on the human and ethical implications of artificial intelligence" [31]. This kicked off Europe's journey towards AI regulation.

When the EU-AI Act comes into play, the EU will be the first major regulator to introduce a law designed specifically to govern AI [32]. In introducing the act the EU is hoping to provide a direction for the rest of the world to follow [33]. The EU can take comfort in knowing it has the ability and experience to lead the way in setting the direction of global digital regulation. Just as with the EU-AI Act, the EU took the lead in creating legislation for data protection with the introduction of the General Data Protection Regulation (GDPR), which has been one of the most significant and impactful laws of the past decade [34]. Following its introduction in Europe, GDPR went on to set the standard for data protection internationally [34]. This track record will no doubt give the EU confidence that it can once again lead the way with the EU-AI Act. Industry experts have expressed confidence that the EU-AI Act will have a significant global impact similar to that of the GDPR [35], attributing this to the EU's regulatory capabilities and its market size, which create strong incentives for compliance [34]. This confidence and experience will be essential for navigating the disruption that will inevitably arise from the introduction of this new law.

The EU-AI Act is expected to come into effect in late 2023 and AI providers will have between 24 and 36 months to comply with the law [5]. Once in place it will be highly restrictive [35] and apply to any AI technology offered within the EU [5, 33]. As a result, it is important for any organisation deploying AI technology on the EU market to anticipate the possibility of being subject to regulation under the AI Act [36]. To adequately prepare an organisation must evaluate the impact of the act on their current mode of operation, identify necessary adjustments to ensure compliance, and develop and implement an action plan to address the identified gaps. If organisations fail to comply within the afforded timeframe they face the risk of substantial fines of up to €6 million or 6% of the organisation's global turnover [5], highlighting for the need for adequate preparation.

As previously demonstrated, the EU-AIA proposes a broad definition of AI that encompasses a wide range of technologies. Since the act will be applicable to various technologies with different capabilities, the powers and risks associated with these technologies will vary. Therefore, the EU-AIA will adopt a risk-based approach to regulation to account for these differences [4, 5]. This risk-based approach will facilitate a sliding scale where, as the levels of risk associated with an AI system increase, the required controls increase [5, 33]. The sliding scale is broken into four categories; unacceptable, high, limited, and minimal. This approach aims to prevent unnecessary restrictions on lower-risk technologies while maintaining appropriate regulation for higher-risk ones. However, it may also introduce complexities in the implementation of the law.

The EU-AI Act is expected to result in increased development and operational costs for AI providers in the EU. Given that AI adoption is a key strategy for both the EU and Irish governments, [1, 7] it is important to evaluate the potential impact of these additional costs on the success of this strategy. It has been noted that SMEs in the EU are subject to existing high costs of regulatory compliance [2, 37]. Therefore, any additional financial burdens on SMEs as a result of the EU-AI Act could prove detrimental to their growth and the success of AI adoption in the EU. This would be detrimental to the strategy as SMEs are already falling behind larger organisations in the field of AI innovation, as is evidenced by the disproportionate number of AI patents awarded to a small number of large multinational firms [38]. To achieve the goal of transitioning to safe AI, the EU and Irish governments need to address the delicate relationship between regulatory burdens on SMEs and AI adoption.

The potential costs associated with the EU-AI Act have been a topic of discussion, with estimates of the impact the act may have on SMEs varying widely. On the pessimistic end of the range estimates for the potential cost range for 40% [35] of an AI projects cost to the lower end of 17% [39]. Concerns have been raised that this may lead to AI development being unsustainable [40]. In addition, the EU is aware that SMEs will have difficulty in financing AI projects [1]. To address this concern the proposed EU-AI Act includes a variety of supports that SMEs can access during the development of AI systems [2]. These measures include European digital innovation hubs (EDIH) and testing & experimental facilities (TEFs), which offer access to research and technical expertise, enabling SMEs to test AI systems before investing [41, 42]. SMEs can potentially reduce their compliance costs by utilising these facilities. It is estimated that the compliance cost of the EU-AI Act will reduce to 9% of an average AI project when these facilities

are taken into account [39]. The incorporation of supports for SMEs will help to mitigate the obstacles to innovation faced by SMEs, contributing to the success of the EU and Irish government's AI goals.

3 Research Design and Method

When formulating the design of a piece of research, it is important to consider the approach taken for theory development. In the case of this research, the aim is to examine the impact of a relatively new phenomenon with limited existing literature. Consequently, an inductive approach is adopted, where data will be collected to explore the phenomenon surrounding SMEs and the EU-AIA, leading to the development of theories based on the findings. A qualitative research design will be employed to meet the research aims. This is important as this research looks to answer how SMEs see the incoming EU-AI act and the effect it may have on their operations and the market. Utilising a qualitative research design will allow for an in-depth understanding of how SMEs perceive how the introduction of the EU-AIA later this year will have on its operations.

According to Saunders et al. [43] semi-structured interviews are appropriate for identifying causality and are appropriate for use in exploratory research. A semi-structured interview is guided by a pre-prepared list of open-ended questions, which the researcher can develop on to gain a deeper understanding of the participant's responses. Adopting this approach will also allow the participants to guide the development and induction of theories. As this study is constrained to the brief time period leading up to the implementation of the EU-AI Act, a cross-sectional study will be performed.

The contents of the semi-structured interviews will be transcribed into text, resulting in a large amount of data. It is important to analyse this data in a structured way to extract meaning from it, to achieve this thematic analysis will be utilised. Thematic analysis is a foundational method for qualitative analysis [44], where the process of analysis involves searching the data set for themes and patterns across it [43]. To ensure this analysis is performed in a structured and reliable process, Braun and Clarke's six-step framework will be followed, that includes: a) familiarisation, b) generate initial codes, c) search for themes, d) review themes, e) define and name themes and f) write report.

4 Results and Analysis

The results can be broadly categorised and visualised as shown in Table 1.

4.1 Perception of the Act

When assessing the participants responses regarding their perception of the EU-AI Act it was noted that most participants expressed negative views on the act. These negative views centred around views that, firstly, the act may quickly become obsolete and secondly, that the act is not necessary due to existing legislation. In contrast, a single participant had positive perception of the act and its necessity. Within the interviews, participants queried the necessity of having a specific act to address the concerns around

Table 1. Summary of themes and subthemes

Themes	Sub Themes	Interview Snippets
Perception of Act	Necessity	*"They're talking about AI exploiting people in terms of data privacy, or in terms of … human rights violations through overgrown enforcement. My question is, [there] existing legislation already applied that can protect people from that?"*
	Obsoleteness	*"AI systems on a two-year time period are going to be indistinguishable from each other, so and I don't know, I think they are going have to move faster than that."*
Operations Impact	Resource Concern SME Disadvantage	*"It will take man hours and resources to comply with the act."* *"Bandwidth is always maximally stretched in a start up, so it's not like I could easily take it on."*
Market Impact	EU Disadvantage	*"You know many companies might decide that that's too much, we're not going to release those models in the European Union because we have to comply with this legislation which would be time consuming, then those models might not be available to us, which would be a shame."*
Communication and Support	Communication	*"I have heard nothing from the government…. I've spoken to enterprise Ireland on it … but in terms of you know communication to companies like mine, about this is coming up, what is your views, things like that, zero."*
	Government Support	*"They're going to add red tape that process things like that. And I think like well they're saying they're going to contribute to the reduction of const, but in reality, increase cost, because you have to pay VAT on those vouchers, and you may not even get the voucher approved."*

AI. Two participants expressed their opinion, highlighting that the risks targeted by the law may already governed by existing legislation. As a result, they questioned the necessity of introducing a separate law specifically addressing AI-related risks.

Findings from the interviews also raised questions surrounding the continued relevance and applicability of laws in relation to the technology they aim to regulate. A perspective highlighted by some participants included the issue of obsoleteness, indicating that laws must adapt and evolve alongside rapidly advancing technologies.

4.2 Operations Impact

Within the broader theme of operational impact, lies the concerns revolving around available resources. This relates to concerns raised by participants regarding the additional resources needed to meet the compliance requirements of the EU-AI Act. Given the limited resources often available to SMEs due to their size, participants expressed worries about the impact that the added compliance commitments could have on their operations. This echoes literature regarding the high regulatory costs that SMEs within the EU already face [2].

The second subtheme focused on the disadvantages that the EU AI market might encounter due to the implementation of the EU-AI Act. Two participants expressed concerns about the availability of cutting-edge AI technologies. Participant 3 expressed the view that organisations developing new AI technology will avoid the EU due to the compliance burdens associated with the act.

4.3 Communication and Support

Across most interviews, participants held negative views around the current governmental communications that surround the EU-AI Act. Four participants expressed that they had not received any communications from the Irish government regarding the introduction of the EU-AI Act. This absence of official information raised concerns and uncertainties among the participants.

As discussed earlier, the government has developed a plan to support organisations through the use of innovation EDIHs. Three participants expressed scepticism regarding the effectiveness of the European digital innovation hubs, which are being introduced to assist SMEs with the compliance and testing requirements of the EU-AIA. Participant 1 raised concerns about whether these hubs would be tailored to meet the specific needs of the industry, casting doubt on their suitability.

5 Conclusion

The first research question aimed to investigate the perceptions of Irish based SMEs regarding the EU-AI Act. The findings revealed that a majority of participants held unfavourable opinions regarding the act. Specifically, these negative views centred around the perceived redundancy of the act, as participants believed that existing laws already covered the risks the EU-AI Act intends to regulate, rendering it unnecessary.

The second research question aimed to investigate the potential impact that the introduction of the EU-AI Act may have on the operations of Irish SMEs and the market in which they operate in. The findings revealed that Irish SMEs anticipate several consequences resulting from the act. Firstly, they expressed concerns about the potential impact

on their resource capabilities, indicating that compliance with the act may impose additional burdens on their limited resources. Such burdens may have a large effect on SMEs operations due to their size. Additionally, participants voiced apprehension regarding the security of the software supply chain, highlighting the threat this could have to their existing product offerings. The research found this may have widespread consequences as it has been common practice in the software industry to develop on top of open source solutions that may be restricted due to the incoming legislation.

The third research question focuses on understanding the response of Irish SMEs in preparing for and complying with the requirements of the EU-AI Act. The research findings reveal that the majority of participants intend to seek assistance from consultancy providers to ensure compliance with the act's requirements. They recognise the need for external expertise to navigate the complexities of the act and ensure their AI systems align with the legal framework. Additionally, participants suggested that, as a result of the EU-AI Act, they may explore opportunities outside the EU market if compliance burdens become overly stringent.

The final research question aims to assess the perception of Irish SMEs regarding the Irish government supports provided to assist with the compliance requirements of the incoming EU-AI Act. The research findings reveal a lack of consistent and effective communication from the government regarding the act's introduction. Furthermore, there are mixed views among Irish SMEs regarding the introduction of innovation hubs, known as EDIHs, intended to assist with compliance requirements.

As this is a new act, it was found in approaching potential interview participants that there was limited knowledge of the act amongst Irish SMEs. Future research would benefit from assessing the perceptions of Irish SMEs during the grace period set out by the act once it is introduced to law and again to assess the changes in perception of Irish SMEs once the act has been established and they have experienced the workings of it in practice.

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Exploring the Impact of Chat GPT and Critical Thinking on Consumer Engagement in Cognitive Marketing: An Empirical Study with Early Adopters

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Abstract. This study aims to examine the role of critical thinking in revolutionizing cognitive marketing by exploring the impact of Chat GPT on enhancing consumer engagement. The study employs a quantitative survey approach to collect data from early adopters, using constructs such as critical thinking, perceived ease of use, perceived usefulness, task technology fit (TTF), consumer engagement, and intention to use Chat GPT. The study is novel in that it examines the role of critical thinking in optimizing the use of Chat GPT for consumer engagement, which has not been explored extensively in previous research. A novel construct, namely Propensity to Diffusion of Innovation, is identified that adds to the diffusion of innovation theory. The findings of this study reveal propensity to the diffusion of Chat GPT is positively related to customer engagement, while critical thinking partially moderates the relationship between them. The results are expected to provide new insights into how critical thinking can be leveraged to improve the effectiveness of cognitive marketing strategies using Chat GPT, ultimately benefiting businesses and consumers alike.

Keywords: Cognitive Marketing · Chat GPT · Critical Thinking · diffusion

1 Introduction

1.1 A Subsection Sample

Cognitive marketing is an emerging field that uses "Artificial intelligence (AI) and Natural Language Processing (NLP)" to engage customers in personalized conversations. Chat bots are one of the most popular forms of AI used in cognitive marketing [1]. However, traditional rule-based chat bots have limitations in their ability to understand natural language and provide meaningful responses. Chat GPT, a state-of-the-art AI language model developed by Open AI, has the potential to overcome these limitations and provide more engaging and personalized customer experiences. In this paper, we examine the diffusion of Chat GPT in cognitive marketing and its impact on customer

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engagement. This research aims to investigate the role of critical thinking in revolutionizing cognitive marketing and the effectiveness of Chat GPT in enhancing consumer engagement. The study will use constructs such as "perceived ease of use, perceived usefulness, task technology fit (TTF), consumer engagement", and intention to use Chat GPT. The research will be conducted from an industrial marketing perspective, with a focus on the effectiveness of Chat GPT in enhancing customer engagement in B2B settings.

The results of this study will contribute to the existing literature on cognitive marketing, critical thinking, and the use of Chat GPT in B2B marketing. The findings will be of significant value to marketers and business leaders looking to leverage AI and cognitive computing in their marketing strategies. By identifying the factors that influence the effectiveness of Chat GPT in enhancing consumer engagement, this research will provide insights into how businesses can improve their marketing efforts and increase customer loyalty.

While there has been some research on the use of cognitive computing in marketing, there is a lack of research on how critical thinking can enhance cognitive marketing strategies. Furthermore, there is a need for more empirical evidence on the effectiveness of Chat GPT in enhancing consumer engagement in B2B settings. In light of the need of the current debate on Chat GPT following research questions are explored in this study.

1. How does the use of critical thinking in cognitive marketing strategies enhance consumer engagement in B2B settings?
2. What factors influence the intention to use Chat GPT in B2B marketing settings?
3. How can businesses effectively diffuse Chat GPT into their marketing strategies to improve consumer engagement in B2B settings?

2 Literature Review

Cognitive marketing refers to the use of cognitive technologies such as Artificial Intelligence (AI) and machine learning in marketing. The application of AI in marketing has revolutionized the way marketers approach their tasks, enabling them to collect, analyze and interpret data more efficiently. One of the earliest papers in this field was by [2], who proposed a "conceptual framework" for cognitive marketing. The authors argued that cognitive technologies such as AI, machine learning, and natural language processing can enable marketers to analyze customer data and behavior to provide personalized experiences. The authors also suggested that cognitive marketing could enhance customer engagement and loyalty, leading to increased sales and profitability.

Several papers in the Industrial Marketing domain have explored the application of AI in various marketing domains. For instance, [3] examined the history, architecture, design, and development of chatbots, which are AI-powered conversational agents used for customer service. The author argued that chatbots could improve customer engagement and satisfaction by providing quick and efficient support. Furthermore, chatbots could enhance brand image and loyalty, leading to increased sales and profitability. A paper by [4, 5] explored the application of AI in customer relationship management (CRM). The authors argued that AI can enable marketers to analyze customer data and behavior to personalize marketing efforts, improve customer retention, and increase

sales. The authors also suggested that AI could enhance customer satisfaction and loyalty by providing quick and efficient support.

Apart from enhancing customer engagement and satisfaction, AI can also enable marketers to optimize their marketing efforts. For instance, [2] proposed a framework for AI-powered marketing optimization. The authors argued that AI can enable marketers to analyze customer behavior, predict demand, and optimize pricing strategies. The authors also suggested that AI could improve marketing efficiency and effectiveness, leading to increased sales and profitability. Despite the potential benefits of AI in cognitive marketing, some challenges still exist. For instance, [6] argued that AI adoption in marketing requires significant investment in technology, infrastructure, and human resources. The authors suggested that firms need to develop a strategic plan for AI adoption and build a culture of innovation to ensure successful implementation of technologies to enhance marketing processes. According to [2, 4, 5], cognitive marketing involves using cognitive technologies to enhance marketing processes. The authors argue that cognitive marketing can help organizations to better understand their customers, identify their needs and preferences, and tailor their marketing strategies accordingly. Furthermore, cognitive marketing can help organizations to automate repetitive marketing tasks, enabling marketers to focus on more creative and strategic aspects of their work. In their study [2–5] analyze the potential of cognitive marketing to enhance customer engagement in B2B contexts. The authors suggest that cognitive marketing can help organizations to create personalized experiences for their customers by providing relevant content and recommendations. Moreover, the authors argue that cognitive marketing can help organizations to develop more effective lead generation and nurturing strategies.

3 Methodology

The study is conducted in two parts first we have used convenient sampling to identify 50 respondents to check the consistency and reliability of the questionnaire. The initial results show adequate consistency and reliability. IN Part two conducted a random survey of 500 marketing professionals and used Structural Equation Modeling (SEM) to analyze the data. The survey included questions related to the use of Chat GPT in enhancing consumer engagement, the critical thinking skills of the consumers, and their overall satisfaction with the Chat GPT experience.

A. Research Design

Research Approach

To analyse the role of critical thinking to enhance the use of Chat GPT, we identified the various constructs related to diffusion and technology acceptance model. The extent research suggested that following constructs are useful to conduct the empirical study and make rational decisions.

1. Customer Engagement (CE): This refers to the level of interaction between a customer and a product or service. In this case, it refers to the extent to which a customer engages with Chat GPT.
2. Critical Thinking (CT): This refers to the ability of an individual to analyze information objectively, evaluate arguments and make rational decisions.

3. Perceived Ease of Use (PEU): This refers to the degree to which an individual believes that using Chat GPT is easy.
4. Perceived Usefulness (PU): This refers to the extent to which an individual believes that using Chat GPT will help them achieve their goals.
5. Task Technology Fit (TTF): This refers to the degree to which an individual perceives that Chat GPT is compatible with their tasks or needs.
6. Intention to Use Chat GPT (ITU): This refers to an individual's intention to use Chat GPT.
7. Authors have introduced a new second-order construct The "propensity of diffusion" refers to the likelihood or tendency of a technology or innovation to spread and be adopted by users or consumers. In the case of Chat GPT, the propensity of diffusion refers to the likelihood of its usage becoming widespread and adopted by a large number of users. It is composite of PEU, PU, TTF and ITU.

Hypothesis Development

As Chat GPT is in its early stage of introduction, but its gained popularity in a very short period of time [7]. Academicians and practitioners are identifying the probable disruption opportunities by this technology [8]. However, some early signs of use of Chat GPT and similar AI based products are seen marketing and content creation [9]. The use of Chat GPT in campaign design and generating the user friendly content are evident [10–12]. Prior research has suggested that innovative technologies can improve customer engagement by providing more personalized and interactive experiences, and that critical thinking can enhance the quality of decision-making and problem-solving [13].

The theoretical explanation for the proposed hypothesis(Fig. 1) is based on the premise that Chat GPT is an innovative technology that has the potential to improve customer engagement by providing personalized and interactive experiences. The degree to which Chat GPT is adopted by users (i.e., the propensity of diffusion of Chat GPT) is expected to positively influence customer engagement, as users who are more familiar with the technology are likely to have a more positive attitude toward it and use it more frequently [14–16].

Furthermore, critical thinking is hypothesized to partially mediate the relationship between innovation diffusion and customer engagement. This is because critical thinking skills are essential for making informed decisions and solving complex problems, which are important aspects of engaging with innovative technologies such as Chat GPT. Previous research has shown that critical thinking skills can improve the quality of decision-making and problem-solving, as well as enhance learning outcomes [13].

Therefore, the conceptual model proposes that the positive relationship between the propensity of diffusion of Chat GPT and customer engagement is partially mediated by critical thinking skills. Specifically, users who possess strong critical thinking skills are expected to be more engaged with Chat GPT, as they are better equipped to understand and navigate the technology, identify potential issues and opportunities, and generate new ideas for how to use the technology in innovative ways. Hence, we posit:

H1*: Propensity of diffusion of Chat GPT is positively related to Customer Engagement*

***H2**: Propensity of diffusion of Chat GPT is also positively associated with Critical Thinking*
***H3**: Critical Thinking positively associated with Customer Engagement*

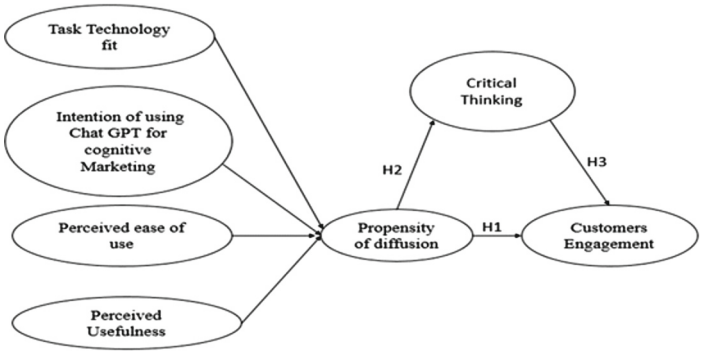

Fig. 1. Proposed model

3.1 Data Collection Method

Data were collected using a pre validated questionnaire. The questionnaire was sent to marketing professionals using social media (LinkedIn). Snow ball technique is used to enhance the response rate. Out of 200 responses we classified them as "innovators, early adopters, early majority, late majority, and laggards". To avoid endogeniety bias, out of 150 early adopters and innovators, 84 responses are randomly selected for the analysis. The questionnaire identifies the early adopters and these 84 responses are taken who are confident to use Chat GPT for their marketing campaign. The reliability of the measurement scales is calculated (Cronbach Alpha) using R software. The Cronbach Alpha for all the constructs are greater than 9.

4 Results and Discussion

The conceptual model is tested with path analysis using R, Lavaan Package. The fit indices are as per the stated values for a good fit. Model shows a good fit. The measurement model correlation table clearly indicates that PU, PEU, TTF, and ITU exhibits high degree of correlation hence they represent a latent variable called **propensity of diffusion (DFI)**. Further the shows that the model also exhibits a good discriminant validity, as the data shows the correlation values for the constructs Propensity of diffusion (DFI), CT and CI are less than 0.5. We used Structural Equation Modelling (SEM) to test the hypotheses. SEM uses path model to validate the model and hypotheses. Figure 2 shows the hypothesized relationship the SEM regression revels that H3 is not significant at 95% level of significance. H1 and H2 are significant. Hence we conclude a new structural model after testing the hypothesis. Table 1 depicts the regression results where, H1 and H2 are significant while H3 is not significant.

Table 1. Results

Hypothesis	Regressions:	Estimate	Std.Err	z-value	P(>|z|)	Remark
	CE ~					
H3	CT	0.167	0.104	1.615	0.106	Not Proved
H1	DFI	1.214	0.225	5.382	0.000	Proved
	CT ~					
H2	DFI	0.21	0.102	2.062	0.039	Proved

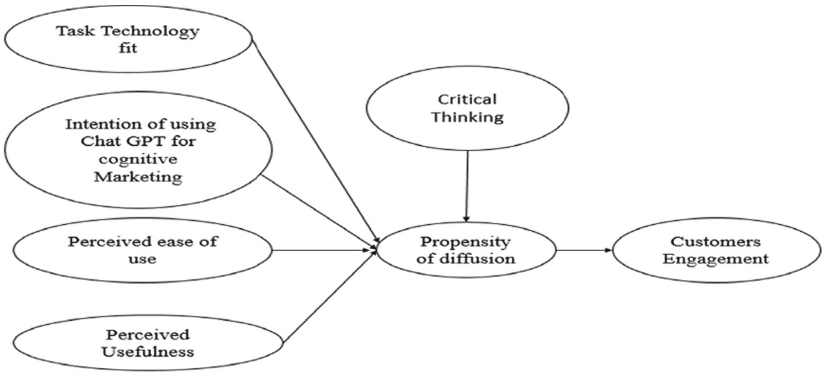

Fig. 2. Final structure of proposed model.

4.1 Discussion of Findings

The study tested hypotheses related to the relationship between the variables in the model. Specifically, it found that the Propensity of Diffusion of Chat GPT has a high degree of probability of generating engaging content in cognitive marketing. However, the study did not find evidence to support the hypothesis that Critical Thinking mediates this relationship. Instead, it found a positive association between Critical Thinking and Propensity of Diffusion of Chat GPT. The study used SEM to test a theoretical model of the relationships between several variables related to the Propensity of Diffusion of Chat GPT and its ability to generate engaging content in cognitive marketing. The researchers proposed a new model structure, which they tested for both convergence and validity using R software.

The results of the SEM analysis showed that the new model was both convergent and valid, indicating that it was a good fit for the data. The study then used the model to test several hypotheses about the relationships between the variables. The study found that the Propensity of Diffusion of Chat GPT was highly likely to generate engaging content in cognitive marketing. However, the study did not find evidence to support the hypothesis that Critical Thinking mediated this relationship. Instead, the study found a positive association between Critical Thinking and Propensity of Diffusion of Chat GPT. This suggests that while Critical Thinking may not directly affect the ability of

Chat GPT to generate engaging content, it may play a role in increasing the overall Propensity of Diffusion of Chat GPT. The study's findings provide important insights into the complex relationships between these variables and highlight the need for further research in this area.

4.2 Theoretical and Practical Implications and Recommendations

The study identifies a new latent variable, Propensity of Diffusion of Chat GPT, which may be an important factor in understanding the ability of Chat GPT to generate engaging content in cognitive marketing. New construct may be useful to explain the diffusion of innovation theory in other similar cases. The study highlights the importance of considering both direct and indirect effects of variables in theoretical models, as the relationship between Propensity of Diffusion of Chat GPT and its ability to generate engaging content was not mediated by Critical Thinking, but there was a positive association between the two variables. The study's findings contribute to the broader literature on the use of artificial intelligence (AI) in marketing and highlight the need for further research to better understand the complex relationships between AI, marketing, and consumer behavior.

The study's findings suggest that organizations using Chat GPT in cognitive marketing should focus on increasing the Propensity of Diffusion of Chat GPT to maximize its ability to generate engaging content. The study's findings also suggest that organizations may want to consider incorporating strategies that promote Critical Thinking among consumers to increase the overall Propensity of Diffusion of Chat GPT. The study highlights the potential benefits of using AI in marketing and provides insights into how organizations can optimize their use of AI tools to improve marketing outcomes. Based on the study's findings, organizations should consider investing in strategies that increase the Propensity of Diffusion of Chat GPT and promote Critical Thinking among consumers. Organizations may also want to explore the use of other AI tools and techniques to further enhance their marketing efforts.

5 Conclusion and Future Directions

The identification of the Propensity of Diffusion of Chat GPT as a latent variable adds to the theoretical understanding of how AI technology can be used effectively in cognitive marketing. The study's findings highlight the importance of examining both direct and indirect effects of variables in structural equation modelling, as it can reveal important relationships and help build more comprehensive theoretical models. The study contributes to the growing body of research on AI in marketing and consumer behavior, providing insights into how organizations can effectively leverage AI tools to improve marketing outcomes.

While the present study provides valuable insights into the relationship between the Propensity of Diffusion of Chat GPT, engaging content generation, and critical thinking, there are certain limitations to this study that need to be acknowledged. One limitation of this study is the use of a single data collection method, i.e., online surveys, which may limit the generalizability of the findings. In future research, it may be beneficial to use

a variety of data collection methods, such as interviews, to obtain more comprehensive and diverse data.

Another limitation is the sample size used in this study. While a sample of 84 participants is considered acceptable for SEM analysis, a larger sample size would provide more statistical power and increase the generalizability of the findings. Finally, the present study did not examine the impact of individual differences, such as personality traits, on the relationship between the Propensity of Diffusion of Chat GPT, engaging content generation, and critical thinking. Future research should explore these factors to better understand the complex relationships between these variables.

In terms of future research directions, one area that warrants further investigation is the use of Chat GPT in other marketing contexts beyond cognitive marketing. Additionally, exploring the impact of different levels of critical thinking on the relationship between the Propensity of Diffusion of Chat GPT and engaging content generation could provide further insights into the mechanisms underlying this relationship. Furthermore, it would be interesting to investigate the effectiveness of different approaches to enhance critical thinking skills in the context of Chat GPT usage. Such an investigation could provide guidance for organizations seeking to improve their content generation strategies through the use of Chat GPT. Future research should continue to explore the complex relationships between AI, marketing, and consumer behavior to better understand how organizations can effectively use AI tools to improve marketing outcomes.

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Between Uncertainty and Familiarity: A Study on Office Workers' Trust in AI

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Abstract. As Artificial Intelligence (AI) technology becomes more prevalent in professional occupations, it's vital to comprehend the elements that shape how these workers interact with and trust AI systems. This study delves into how attributes resembling both the system and humans influence the way office workers view and interact with AI enabled workplace applications (AI-EWAs). Using Uncertainty Reduction Theory (URT), the Computer as Social Actors (CASA) model, and considering the Uncanny Valley Effect (UVE), we investigate how these system-like and human-like traits affect user experiences and trust among office workers.

URT highlights how system-like features in AI reduce uncertainty for office workers, enhancing their understanding, decision-making, and data management. This fosters trust and reduces uncertainty. Concurrently, the UVE warns that as AI becomes more human-like, it can reach a point of discomfort and reduced trust. Designing AI applications requires careful balance to avoid triggering this effect. Conversely, the CASA model highlights the importance of human-like attributes, such as personification and social cues, in shaping how office workers perceive and interact with AI applications. CASA suggests that individuals frequently apply the same expectations and social norms from human-to-human interactions (HHI) to human-to-computer communications (HCI). Incorporating human-like traits in AI design fosters familiarity and social connection, promoting engagement, satisfaction, and trust among office workers while avoiding the UVE. By exploring both system-like and human-like features, along with understanding the UVE, this research aims to provide a comprehensive insight into factors that affect trust and interactions with AI-EWAs among office workers. Our findings will inform the design of AI systems that blend traits to enhance user experiences, trust, and acceptance in the workplace. This research offers insights for companies, solution architects, and HR managers implementing AI solutions, considering office workers' perspectives and the implications of the UVE.

Keywords: Trust · office workers · Computers as Social Actors (CASA) · Uncertainty Reduction Theory (URT) · Uncanny Valley Effect (UVE)

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1 Introduction

Today we are seeing the introduction of cutting-edge technology into the working environment; technologies that have the capability of doing tasks without human intervention [1]. Businesses adopting AI technologies are expected to reap rewards like increased profits, cost reductions, and improved operational efficiency [2]. One of the primary focuses of study within the Information Systems (IS) field is on the ways in which employees adopt, react to, and engage with newly deployed IS in the workplace [3]. Office employees, in general, are vital contributors to the growth, productivity, and overall prosperity of contemporary economies [4]. Aligned with this perspective, industry leaders anticipate the extensive adoption of AI technologies. Forbes, for instance, conducted a survey involving over 300 executives, revealing that 95% of the participants foresaw AI playing a crucial role in their organizations going forwards [5].

Despite these advancements, research has indicated that human perspectives can lead to behavioural reactions that impact an organization's capacity to effectively utilize emerging technologies [6]. Considering the anticipated incorporation of AI into employees' workplaces, a salient concern arises regarding employees' willingness to use AI within the workplace. Technophobia, a specific fear of technology, is a common manifestation of apprehension and distress towards innovative technological advancements, such as robots. [7]. According to established theories in the field of human behaviour, such as the work of Gibb [8] and Hausman [9], it is posited that individuals' behavioural intentions are motivated by a combination of emotional and cognitive factors. These cognitive factors include beliefs, such as trust, which play a substantial role in modelling human behaviour. Trust has been demonstrated to have a large influence on users' willingness to use and subsequent adoption of various technologies [10]. Trust is crucial in encouraging people to adopt new technologies by reducing perceived risks [11]. Moreover, trust in AI is essential for the fourth industrial revolution, as emphasized by the European Commission [12]. The shift in power and authority from humans to computers, along with the changing perspective of human-technology relationships to human-AI interactions, are two factors that distinguish trust in AI from trust in traditional methods that do not involve AI [13].

It is still unknown if uncertainty reduction scripts designed for human-to-human interactions will be applicable to those designed for human interactions with AI [14]. A crucial question is whether those things that have been shown to work in the past to build trust between individuals will also work between individuals and AI. Based on the analyses conducted by, Clark, Pantidi, Cooney, Doyle, Garaialde, Edwards, Spillane, Gilmartin, Murad and Munteanu [15], humans have a unique perspective on technology interaction, and human trust concepts may not apply to human-machine trust i.e. they view the interaction as transactional and not social. When people process information, they often use heuristics, also known as mental shortcuts, in order to reduce uncertainty and make efficient use of their cognitive resources [16]. Past research has underscored the common perception among individuals that machine cues inherently denote an unbiased and impartial standpoint, a notion often encapsulated in the term "machine heuristic" [17]. Yet, this widespread belief in the unerring objectivity and impartiality of machines has been contested by several researchers who highlight that it is, indeed, not always valid [18]. Studies are casting light on the fact that AI, far from being wholly objective,

may inadvertently harbor unconscious biases [19]. Given this, it becomes increasingly pertinent to explore the mechanisms and circumstances under which individuals resort to machine heuristics during information processing.

Reducing uncertainty is essential for establishing trust in both interactions between humans and interactions between humans and machines. This involves enhancing an individual's ability to anticipate and comprehend the behaviours of the party or system they are interacting with [20]. Building upon this complex issue of human-likeness in AI, we explore the URT for further insight. URT suggests that minimizing uncertainty about others during initial interactions improves the ability to predict future behaviour, understand motives, and consider contextual factors [21]. Studies have shown that trust and uncertainty have a relationship that is inversely proportional to each other [22]. Building trust is challenging, especially in early interactions with unfamiliar parties, and becomes more pronounced when the interaction involves an AI, amplifying uncertainty [23]. Previous studies have shown that a positive correlation was observed between uncertainty and the intention to use AI [24]. Through URT, we can explore the impact of predictability and understanding on AI acceptance and its role in mitigating potential negative effects like the UVE caused by highly human-like AI. As people interact more frequently with others, their trust in them tends to increase over time. However, their trust in technology often declines due to past experiences with malfunctions and errors [25]. The success of smart systems depends on the users' openness to interacting with and trusting the systems' suggestions. As a result, it's crucial to learn what these systems' end users anticipate, as well as what factors must be considered, in order to lessen resistance and ensure their widespread adoption [26]. This leads us to our first research question.

RQ1: Does trust impact the willingness to use AI-EWA among office employees?

It's generally believed that the greater the resemblance of an AI to a human, the higher the likelihood of it being trusted and accepted by people [27]. Anthropomorphism involves imbuing AI systems with human-like characteristics in their design. However, research has shown that excessive anthropomorphism might cause users to overestimate the AI's abilities, which could in turn harm the degree of trust they place in it [28]. Studies have demonstrated that in specific circumstances, enhancing the human-like qualities of technology can yield positive outcomes, such as increased trust among users [29]. However, in certain instances, the incorporation of social cues resembling those of humans has resulted in unfavourable outcomes such as social anxiety, decreased cooperation, dishonesty, and eeriness [30]. This perceived 'humanness' and system-like qualities in AI technologies often provoke a tension between paradigms like the CASA framework and the UVE [31, 32]. The CASA approach posits that individuals react positively to AI technologies that display sufficient human-like characteristics [33]. Conversely, the UVE suggests that too much 'humanness' in AI technologies can lead to discomfort and decreased trust [30]. Therefore, when considering employees and workplace applications, it becomes vital to balance between system likeness and human likeness to avoid the activation of the UVE.

Despite extensive research on the influence of trust on the willingness to use workplace applications enabled by AI, there's a significant gap in understanding whether office employees prefer AI-EWAs that display human-like or system-like characteristics. This ambiguity leaves organizations in a challenging position while adopting and

implementing AI solutions. Do employees respond better to AI applications that mimic human behaviours, as suggested by the CASA paradigm, or does the UVE take precedence, leading to discomfort with overly human-like AI? This unexplored area calls for further investigation to help businesses optimize their AI strategies and ensure effective acceptance and use of such innovations in the workplace. The objective of this research revolves around exploring the impact of trust on employees' willingness to engage with AI-EWAs that exhibit either human-like or system-like characteristics. This leads us to our next two research questions.

RQ2: What impact do human-like features of AI-EWAs have on trust in AI among office employees?
RQ3: What impact do system-like features of AI-EWAs have on trust in AI among office employees?

Ultimately, the successful integration of AI in the workplace hinges upon a comprehensive understanding of these varied perspectives, enabling the design and development of AI technologies that are not only sophisticated and efficient but also user-friendly and trusting.

2 Theory and Hypothesis Development

2.1 Trust and Uncertainty Reduction Theory

Traditionally, trust applied to interpersonal relationships, but it has now expanded to include human-computer interactions with the rise of intelligent systems. According to Mayer, Davis and Schoorman [34], trust can be understood through three primary dimensions: ability, benevolence, and integrity. However, various perspectives exist within the realm of technology. A proposed categorisation of trusting beliefs into performance, process, and purpose was presented by [35]. In contrast, Lippert and Michael Swiercz [36] proposed that function, reliability, and predictability should be considered. Law and Scheutz [37], suggest a division of trust into Performance-Based Trust (PBT) and Relation-Based Trust (RBT). The concept of PTB pertains to the AI's ability to execute its designated task or tasks with reliability, capability, and competence, without necessitating human supervision. The formation of PBT in AI hinges on several factors, including its transparency in operation, responsiveness to user inputs, and predictability in behaviour. The concept of RBT pertains to the trust that is placed in an AI as a social agent. Individuals who interact with the AI may exhibit emotional vulnerability and place trust in the AI's sincerity and ethical conduct. McAllister [38] proposed that trust may manifest as both a cognitive construct, rooted in rational thought processes, and an emotional construct, rooted in affective response. According to research conducted by Glikson and Woolley [13], the primary impacts of aspects on emotional trust are immediacy behaviours, anthropomorphism, and tangibility, and the primary impacts of aspects on cognitive trust are task characteristics, reliability, and transparency. Employee trust in AI technology is instrumental in unlocking the advantages and reaping the benefits associated with AI in businesses [39]. The perception of trust, as held by employees, is more significant than the actual trustworthiness of AI [40]. Therefore, utilizing employees' insights and engagement is essential for successful technological changes within

an organization [41]. Progress in technology is heavily swayed by uncertainty [42]. The term "innovation" refers to a process that is synonymous with risk and uncertainty [42]. Without trust, innovative technology is not feasible [43]. URT is based on the notion that when unfamiliar individuals come together, their main objective is to establish causal frameworks to make sense of their own behaviour and the behaviour of others [21]. Within the technology sector, this uncertainty originates from an individual's perception that they are not fully equipped to precisely predict or deeply understand the intricacies of the technological environment [44]. Therefore, according to URT, reducing uncertainty plays a crucial role in building trust in both interactions between humans and interactions between humans and machines. This involves enhancing an individual's ability to anticipate and comprehend the behaviours of the party or system they are interacting with [20]. Therefore, understanding how URT can be utilized to increase trust and reduce uncertainty will be crucial as we navigate between human and AI interactions in the workplace.

2.2 Research Framework

The research framework diagram, in Fig. 1, illustrates the relationship between system-like and human-like features, trust, and willingness to use AI. This framework guides our research into understanding how these variables influence office employees' willingness to use AI-EWAs.

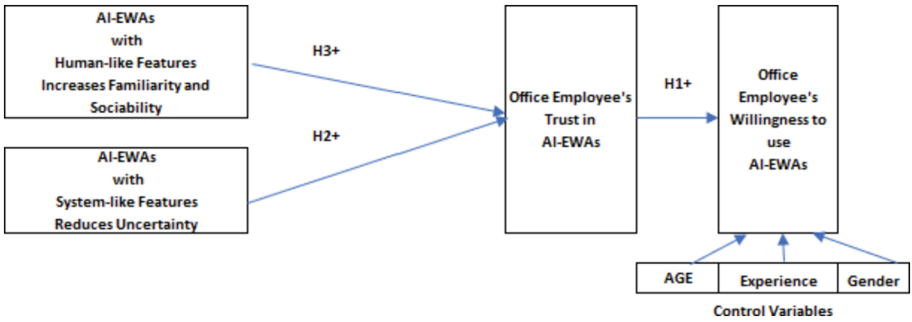

Fig. 1. Research model for the office employee's willingness to use AI-EWAs

Willingness to use AI (WTU-AI) and Trust (TRT). Trust has long been a core notion in technology acceptance studies and has been shown to be a crucial driver of humans' readiness to accept and willingness to utilise a technology since it reduces uncertainty and risks associated with vulnerabilities [45]. Trust goes beyond HHI and has been acknowledged as a pivotal element in human-computer [46], human-robot [47], and human-automation [48] relationships. Recent research has indicated that there is a need for increased attention to trust in relation to how individuals engage with technologies based on AI [49]. Gaining a deeper understanding of how trust operates in the dynamic relationship between humans and intelligent machines is becoming increasingly vital as AI and other types of intelligent technology grow more pervasive in our daily lives

[50]. The establishment of trust between humans and AI plays a critical role in enabling effective collaboration between the two entities within enterprises. This is due to the potential for trust to mitigate the perceived risks associated with AI, thereby promoting a more seamless and productive working relationship [13].

Researchers have explored individuals' WTU-AI to adopt new technology [51]. The findings of many of these studies have led researchers to the conclusion that trust positively contributes to users' WTU-AI [52]. Based on the previous findings, trust influences the connection between intention to use and actual behaviour [53]. This was supported by research conducted by Sutarso and Setyawan [54], who found that trust positively impacted intention to use. While existing literature on AI trust has made significant contributions, there remains a lack of clarity regarding the impact of trust on office employees' willingness to use AI. Consequently, there is a pressing need to conduct further research to explore the intricate role of trust in shaping AI acceptance. Numerous studies have demonstrated a strong positive correlation between trust and WTU-AI [52]. Based on these studies, this research hypothesizes that:

Hypothesis 1: TRT will have a positive impact on WTU-AI.

System-Like Features (SLF). The concept of trust and interaction with computers is subject to contrasting viewpoints. While the CASA paradigm highlights the role of social attributes in trust formation, alternative perspectives offer different insights. The functional approach, for instance, views computers primarily as functional tools designed to fulfil specific tasks rather than social actors. From this viewpoint, trust in computers is based more on their reliability, performance, and task completion than on social attributes. According to Obar and Oeldorf-Hirsch [55], Individuals frequently consent to privacy terms and freely share personal data without fully considering the potential risks and consequences. This phenomenon is attributed to the machine heuristic, where individuals use mental shortcuts to assess situations by assigning them machine-like characteristics that shape their inclination towards machine entities rather than human entities [56]. This heuristic is grounded in the belief that machines are commonly regarded as possessing greater objectivity than humans, demonstrating higher precision in task execution and enhanced security in handling information [18]. According to the model, when individuals perceive their interactions to be with a machine rather than a human, they are inclined to apply preconceived stereotypes typically associated with machines. These stereotypes include characteristics such as being mechanical, objective, and ideologically unbiased. Studies have shown that machine heuristics positively impact trust and WTU-AI [57]. According to Sundar [56], the less human-like an interface appears, the more objective its judgements are considered to be. The socio-technical perspective, which considers the reciprocal relationship between humans and technology, emphasizes the importance of usability, perceived usefulness, and alignment with user needs in shaping trust in technology. This perspective acknowledges that trust is influenced by various contextual factors beyond social attributes [58].

Researchers have found that anthropomorphism has a detrimental influence on people's WTU-AI technologies [59]. Anthropomorphism, for instance, was suggested by Lu, Cai and Gursoy [60] to generate a feeling of danger that undermines people's willingness to embrace service robots. Recent studies exploring human-agent interaction,

have linked this to the UVE [61]. As a result, this may have an adverse impact on the observer's trust in the agent. Thus, the anticipation and prevention of UVE are crucial aspects in the design and development of AI applications. Gambino et al. [57] suggest that to enhance the acceptance and utilization of innovative technologies, it is advisable to design applications that cater to technologically proficient users with strong convictions in machine heuristics. Rather than focusing on anthropomorphism, the emphasis should be placed on optimizing functionality during the design process. In the context of this research, we aim to investigate the impact of system-like features of AI-EWAs on trust among office employees. By considering the URT and UVEs, we recognize the potential influence of machine heuristics in shaping trust.

Hypothesis 2: System-like features positively influence trust.

Human-Like Features (HLF). The general consensus is that an AI has a higher chance of earning people's trust and acceptance the more humanlike it appears to be [27]. The CASA perspective emphasizes the role of social cues and human-like qualities exhibited by computers in shaping users' trust and interaction patterns [62]. In line with CASA, when computers exhibit social attributes, individuals tend to mindlessly transfer social scripts and behaviours from humans to computers [32]. The application of the CASA paradigm to the study of human-like traits has yielded findings that show positive results [63]. Studies have shown that individuals exhibit a greater level of trust in and acceptance of technology when they engage with technology that possesses a physical appearance resembling humans and demonstrates social competence similar to that of humans [64]. It has been determined that creating expert systems with human-like characteristics influences people's perceptions and trust [29]. Interaction studies between humans and robots have demonstrated that people's views of a robot's intellect, comfort, and trustworthiness all improve as the bots becomes more humanlike [65].

Humans have a natural inclination to establish connections with others, and in the absence of such connections, they can form humanlike bonds with inanimate objects through anthropomorphism [66]. Therefore, researchers suggest that the humanlike aspects are distinct technical traits that have the potential to impact users' perceptions of the technology as well as its adoption and ongoing usage [67]. In addition, studies conducted in the field of intelligent systems have shown that anthropomorphism may maintain a user's trust in the system even when that system's dependability decreases. This indicates that adding human-like characteristics to intelligent systems could be a strategy to increase the degree to which one can trust such systems [68]. While businesses employ various methods to integrate intelligent workplaces from a human-centric standpoint, comprehending how employees perceive the impact of anthropomorphic designs on trust and sustained usage remains crucial [69]. In the context of this research, we aim to investigate the impact of human-like features of AI-EWAs on trust amongst office employees. By considering the CASA theory, we recognize the potential influence of social cues and human-like qualities in shaping trust.

Hypothesis 3: Human-like features positively influence trust.

3 Proposed Methodology and Future Work

The research will use a mixed-methods approach in two phases: first, a systematic literature review will be conducted, followed by interviews with office employees to explore human-like and system-like features in their use of AI-EWAs. Any questionnaire adjustments will be based on interview findings The second phase will involve testing the hypothesized model using surveys to investigate the role of trust in office employees' willingness to use AI-EWAs. The primary study will involve a larger and diverse sample size. A 5-point Likert scale will be employed, and surveys will be distributed via SurveyMonkey to office employees from various organisations.

4 Expected Contribution

This research is set to provide critical insights into the factors affecting office employees' acceptance and use of AI, with a particular emphasis on preferences for human-like or system-like workplace applications. Notably, it seeks to illuminate the role of UVE in AI adoption and its implications for system design. The study will build on URT, CASA, and the machine heuristic, advancing theoretical understanding. It will offer crucial insights for optimizing AI systems in workplace settings for designers, developers, and managers.

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Proliferations in Algorithmic Control: Review of the Phenomenon and Its Implications

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Abstract. This research explores algorithmic controls, observing the phenomenon through micro, meso and macro perspectives of contextual analysis. Discovered themes across reviewed papers are classified at the three levels and overlaps. Study across 31 high relevance research papers helps develop an initial nomological network of the primary emerging themes. The proposed network consists of evolution and implication factors for algorithmic control. Factors like individual adoptions, institutional focus areas, technology, mediators, capabilities, regulatory and other guidance were observed of primary relevance and form the 'evolution' side of the network. Significant structural impacts, socio-economic impacts as well as sentiments and concerns were explored form the 'implication' side. The research reveals alignment to chosen industry formats which led to a set of propositions aiding the network development. The intent of this encapsulation is to integrate the emerging knowledge on the phenomenon of algorithmic control through exploratory qualitative research and propose a nomological network indicating evolution and its implications. Understanding these themes is of significance for future academic research and as organizational leaders embrace the power of algorithmic controls for meaningful deployments.

Keywords: Algorithmic Control · Nomological Network · Thematic Analysis · Exploratory Qualitative Research

1 Introduction

Proliferations in artificial intelligence alongside accelerated embrace of digital ways and transactions across organizations, governments unleash new experiences, engagements and outcome paradigms between employees, consumers, citizens, and large institutions. These are increasingly mediated via machine interfaces, intelligences, and algorithms. Emerging focus on future of work, employment, new organizational designs including labor platforms, algorithmic dominance represents an evolving phenomenon. Considered a derivative of the scientific management, algorithms represent the most recent trend in the rationalization or bureaucratization of workplaces. Simultaneously availability of big data enables organizations to predict and control their key processes,

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including material flow optimization, marketing, and work organizations more reliably. Algorithmic management of work is emerging inside and between organizations [1]. Simultaneously, adoption of robotic assistance and collaboration in work processes is likely to increase across industries globally. With such a trend towards applications of algorithm run products, services, and work processes, the need to manage its nuances become critical and triggers the need for structured explorations and establishing associations in this emerging knowledge area. This requires multidimensional explorations to make sense of the transformations and the consequences.

1.1 Research Methodology

The research deploys structured approaches from Saunders methodology [2] and pragmatism in research [3]. The exploration is qualitative and applies inductive research approaches [4]. Themes are assimilated and evaluated across the reviewed literature to categorize into micro-meso-macro and overlapping contexts. Theme based clustering and qualitative analysis is conducted to propose associations indicated through a nomological network. To operationalize multiple keywords like 'Algorithmic Management', 'Algorithm Control', 'Worker Autonomy', 'Gig work', 'Future of work', 'Policy' and others were used to search relevant papers across multiple databases including Scopus, Google Scholar, Web of Science and ScienceDirect. Through the search newer relevant keywords were discovered and used iteratively. With the help of the keywords and the phrases at first 123 peer-reviewed journals, books and book chapters were identified. This initial set was evaluated independently by the researchers to arrive at a subset of 31 research publications in the domain of algorithmic control. This subset bears strong relevance to exploration with minimum variance in choice across the researchers applying purposive sampling methods [5]. Considerations for choice included factors like relevance, keywords, recency of publication, citation of research and importance of the publication platform. The data analysis and extraction, across the 31 articles helps discover key themes and associations to understand the evolution and consequences of algorithmic control. Nomological network [6] is deployed to visualize the thematic associations.

2 Findings

A study across the 31 papers revealed multiple themes emerging in micro-meso-macro and overlapping contexts. Figure 1 indicates a mapping of the themes and the associated context. Further qualitative analysis is conducted to cluster related and associated themes. This helps in reduction of multiple observed variables into meaningful constructs and is instrumental in proposing the nomological network. The following discussion helps understand these constructs and the underlying themes that relate to it.

Based on the key literature reviews, several institutional focus areas have found to be important particularly in the meso-context. Focus on techno-deterministic approach, E-Leadership and data driven management, are some of the major highlights [7, 8], driving 'Algorithmic' training, instructions, evaluations, discipline [9], matching [10], allocation of work and direction, evaluation, rating and reward of workers, planning and strategy [11], outcomes [12], and power [13, 14]. These give rise to concepts such as lifecycle of algorithmic management systems [15], gatekeeping and guiding control, classification of algorithm [9], degrees of automation [10].

The institutional focus areas were plotted in close semblance with individual adoption indicators which were largely observed to be behavioral and contextual. These are particularly relevant in micro-context. The evaluations pointed out to the prevalence of fairness perception [16], trust and emotion [17] bringing it closer to social psychology readings which attempts to decipher the experience of humans with algorithms. The focus on autonomy and experience, lean towards studies which employ socio-technical perspectives [18] to understand organization design. Multiple investigations discuss on value, self-determination, norms, beliefs, power, personal integrity, and ethics delving into dimensions of autonomy, privacy and fairness issues while achieving a fine balance between integrity and compliance [19–23]. This is relevant to establishing algorithmic governance protocols from a meso and wider macro context. Furthering the existing discussions in philosophy, psychology, and human rights on self-determination [22], an extended terminology 'digital self-determination' has gained interest. Digital Self-Determination incorporates the ideas of respecting, embedding, and enforcing peoples' agency [24], rights, interests, preferences, and expectations throughout the digital data life cycle in a mutually beneficial manner for all parties involved [25]. This becomes particularly relevant in design of algorithm mediated work processes and exchanges.

The labour process analysis [26] is relied upon to balance the control, resistance and exploitation discussions in the labour-capital debate, which eventually leads to concerns on de-humanization as evident in multiple instances of algorithmic processes. Gill [27] deciphers a gamut of commitment, control, fulfillment, identity, resistance, regulation issues while understanding the non-optimal positions including sufferings in organizational settings. Gill [27] earmarks to compatibility and coherence as key individual prerogatives in the narratives on algorithms. Meijerink & Bondarouk [28] brings forth the need for personal growth, identity, work satisfaction, sense of accomplishment and sense-making as they study HRM algorithms, which can simultaneously enable/offer and restrain/ limit autonomy and value to workers. There is also a recursive inter-relationship between algorithmic management and worker autonomy/value which they unearth as an outcome. To enhance workers' marketplace bargaining power, Wood, et al. [19] discusses the key individual resources required as skill and reputation. Schafheitle, et al. [29] brings forth a framework to study how datafication technologies, alter or expand traditional organizational control configurations and considers normative concerns as well as employee perceptions to be drivers of re-configuration efforts. Multiple theoretical lenses used in the studies is indicative of the possibilities that lay vested in understanding the ever-evolving individual adoption criteria in relation to working alongside algorithms.

Fig. 1. Algorithm Control Themes relevant in Micro-Meso-Macro and overlapping context.

Several mediator constructs emerge particularly in the works of Rahman [30] which discuss how opaque third-party evaluations in Labor platforms influence workers' reactivity, and what mechanisms contribute to this form of reactivity. Research identifies success on the platform, platform dependence and evaluation setbacks as factors which influence experimental/ constrained reactivity. Bai, et al. [16] considers sensitivity to task difficulty and education levels, as the factors which are impacted by productivity. Wood, et al. [19] explains Marketplace bargaining power to be a key job quality determinant [31] in discussions on particularly remote work. These are relevant in micro-meso context. Continued pursuit around the focus areas manifests through development of varied institutional and individual capabilities attributable to algorithmic control. More and more organizations are building capabilities on people analytics, surveillance [8], feedback calibrations [13], automated work nudges, algorithms to be deployed in regular workplaces [13], which enhances the ability to learn [13]. Hence, we see models with focus on supervised learning, unsupervised learning, reinforcement learning, deep learning [32], technology mediated controls [8], Integrated Assessment Modeling (IAM) [33] etc., further facilitating response speed [13], systems integration, interdependence for decisions [32].

Research indicates that development of capability is mediated via technology proliferation paths. This relates to macro developments in wider technology and innovations. Increased availability of technologies is enabling rise of human-computer interactions, use of digital sensors to collect Big Data alongside proliferations in Artificial Intelligence. Evidence of dominant use cases in large language models and organizational applications [8], with Natural Language Processing (NLP) capabilities leads to multiple insight generations, all feeding into making algorithmic control and governance more robust. Deployment of such capabilities lead to impacts in working models, society, and economy, and in generation of varied sentiments on algorithmic control.

Observed multiple implications from studies, relate to three broad areas including - working with algorithms, socio-economic impacts, amidst emerging sentiments and concerns. Working with algorithms, trends show sub-ordinated agency over platforms [9], work standardization, interface anthropomorphism [13], digital labour platforms, centralization of knowledge, data and control, redefining of tasks and roles [11], job price determination [7] influencing the decisions of organizations and employees with AI recommendations [13]. These decisions typically remain focused towards cost optimization [13], efficiency [10], accuracy, agility, profit maximization [8]. Some other areas observed through research in scenarios of algorithmic control relate to blackbox, sociomateriality, role ambiguity [10], lack of two-way communication [7], and collective productivity [8]. Emerging from a human-machine configuration perspective, possibilities of auditing and augmenting algorithm as well as its acquisition architecture is discussed to enhance organizational reflexivity [34]. This is primarily relevant across meso-macro context.

In work settings with algorithms, research highlights varied outcomes including 'Algorithmic' fatigue, aversion [8], resistance [9, 14], appreciation, co-operation and collaboration, culture, accountability, and formalization. Concepts of autonomy paradox and leader-member exchange fragmentation [8] are seen to be influencing the human machine interactions while negotiating with algorithms [9] along with robotic decisions [7] processes. Embracing of algorithmic controls in work settings, bring out several sentiments and concerns including dominant hype and a looming fear, proliferation of unintended ways [15], 'technological unconscious' and hegemony [14], value-laden assumptions, reductionist approach [33], technostress, information asymmetry [8], undefined locus of control, opacity [30], complexity [13], anxiety [9], uncertainty [10], lack of trust, and confrontation [15]. Interesting academic debates attribute metaphors like Taylorism [7] on steroids to the phenomenon of algorithmic control. These are more relatable at a micro-meso context.

Evolution in algorithmic control and related ecosystems manifests across multiple socio-economic impacts in a macro-context. This is evidenced across research findings on new models of work frameworks, understanding and processes. Gig-economy [35], freelance [8], platform urbanism [10], platformization [11] have not only led to fuzzy organizational boundary [11], but have also led to erosion of democratic control [32], with impacts on equity and democracy [33]. As we move towards a logic-driven society, questions like whether humans might be left out of loop emerge [7]. Scenarios of unequal bargaining [7], biases (including racial) [14], social coalitions [10], trade union non-acceptance, workplace resistance [9], job insecurity and deskilling [11] are emerging considerations and needs necessary mitigations to derive true gains from algorithmic control paradigms and transformed future work processes.

Review of literature reveals multiple means and developments in such mitigations in the form of abiding regulations, compliances and expected guidance. Research indicates moderating influence of regulations and other guidance as algorithmic control gains focus and capabilities globally. These are relevant across meso-macro context. This is of significance in deriving meaningful, purposeful, and sustainable human-centric implications [36]. Literature Review reveals regulations across different geographies, industries and even functions. Narratives around algorithmic controls are observed across ILO code of practice, data rights and laws, AI regulations [7, 11] and new technology agreements [9]. These consider variables like input legitimacy, throughput legitimacy, output legitimacy [8, 32] particularly in relation to algorithmic outcomes, data protection impact assessment [32], national labour representation laws, national interpretation of law [11], protection of personal data [8] including GDPR compliances [9], worker's rights protections, and the lack of protection [7]. Research indicates evidence in algo-activisim [15], leading to increasing narratives around guidance and best practices in adoption of algorithmic control. When it comes to guidance, some dominant findings include FATE (fairness, accountability, transparency, ethics) principles [15]. Fairness-aware machine learning, sensitivity or gradient-based analysis, mimic models, statistical parity, hidden layers [12], procedural equity, logic [33], configurability [14], interpretability and calculated conformity [8] are evolving considerations for algorithm conceptualizations. Amidst such guidance, present deployments and studies of the same reveal concerns on transparency, trust, ethical considerations, policy, practices [8, 11, 15], balancing to establish synergetic relationship [7] between human-centricity and algorithms.

3 Conclusion

The research emphasizes the need for continuous probing and understanding the area of algorithmic control, with interdisciplinary collaborations, and critical engagements. While there are existent alignments among institutional focus areas and individual adoptions, technology mediation is evident, to help embrace the opportunities, moderated by guidance and controls. The evolved nomological network indicates that, deeper understanding of interrelated implications and promotion of inclusive and ethical practices are some of the obligatory needs for harnessing the power of algorithmic control. Overall, a holistic approach combining the socio-legal and ethical considerations would be required for leveraging the benefits of algorithmic control, to serve as a tool for empowerment and societal benefits. In a globalized world with digital proliferations, algorithms are slowly influencing the different actions, processes, and outcomes of the activities. This research is significant in terms of proposing the linkages among the constructs constituting the elements of algorithmic control, which further enables understanding of implications and impacts across wider society, organizations, and individuals. Table 1 constituting the cluster of variables associated with the evolved constructs are presented here followed by Fig. 2 a representation of the nomological network.

Table 1. Associated Variables across the evolved constructs in relation to Algorithmic Control

Concepts (Constructs)	Observations/Variables
Individual adoptions	Perception (Fairness), trust, emotion, autonomy, value, norms, beliefs, experience, privacy, resources (skill, reputation), personal integrity, ethics, self-determination (digital), sense-making, agency, motivation, compatibility, coherence, personal growth, identity, work satisfaction, sense of accomplishment, normative concerns, balance between integrity and compliance
Institutional focus areas	Techno-deterministic approach, E-Leadership, data driven management, **'Algorithmic'** training, instructions, evaluations, discipline, matching, allocation of work and direction, evaluation and rating of workers, and reward of workers, planning and strategy, outcomes, power, lifecycle of algorithmic management systems, gatekeeping and guiding control, classification of algorithm, degrees of automation
Mediators	Success on the platform, platform dependence, evaluation setbacks, sensitivity to task difficulty, education levels, marketplace bargaining power
Capabilities	People analytics, surveillance, feedback calibrations, automated work nudges, algorithms in regular workplaces, ability to learn, supervised learning, unsupervised learning, reinforcement learning, deep learning, technology mediated control, response speed, systems integration, interdependence for decision, Integrated Assessment Modeling (IAM)
Technology	Human-computer interactions, digital sensors, big data, AI, LLMs, NLP

(*continued*)

Table 1. (*continued*)

Concepts (Constructs)	Observations/Variables
Working with Algorithms/ structural impact	Sub-ordinated agency over platforms, Interface Anthropomorphism, digital labour platforms, work standardization, centralization of knowledge, data and control, redefining of tasks and roles, job price determination, cost, efficiency, accuracy, agility, profit maximization, AI recommendations, blackbox, sociomateriality, role ambiguity, lack of two-way communication, collective productivity, modification of power dynamics, **'Algorithmic'** fatigue, aversion, resistance, appreciation, co-operation and collaboration, culture, negotiating with algorithm, robotic decisions, accountability, formalization, autonomy paradox, leader-member exchange fragmentation, cognitive complacency, anticipatory quantification, hidden politics, reactivity (experimental/constrained)
Socio-Economic Impacts	Gig-economy, freelance, platform urbanism, platformization, erosion of democratic control, impacts on equity and democracy, fuzzy organizational boundary, logic-driven society, humans might be left out of loop or humans in loop, unequal bargaining, biases (including racial), social coalitions, trade union acceptance, workplace resistance, job insecurity, deskilling, lack of social security, low pay, social isolation, work fragmentation, causalisation, precarisation, privacy concerns
Sentiments and concerns	Dominant hype and a looming fear, proliferation of unintended ways, 'technological unconscious' and hegemony, value-laden assumptions, reductionist approach, technostress, information asymmetry, fear, locus of control, opacity, complexity, anxiety, uncertainty, lack of trust, confrontation, Taylorism on steroids

(*continued*)

Table 1. (*continued*)

Concepts (Constructs)	Observations/Variables
Regulations	ILO code of practice, data rights and laws, new technology agreements, AI regulations, input legitimacy, throughput legitimacy, output legitimacy, data protection impact assessment, national labour representation laws, National Interpretation of law, protection of personal data, GDPR compliances, worker's rights protection, and lack of protection, algoactivisim
Guidance	FATE principles, fairness-aware machine learning, sensitivity or gradient-based analysis, mimic models, statistical parity, hidden layers, procedural equity, configurability, interpretability, calculated conformity, logic, transparency, trust, ethical considerations, policy, practice, human-in-command, synergetic relationship between human beings and algorithms

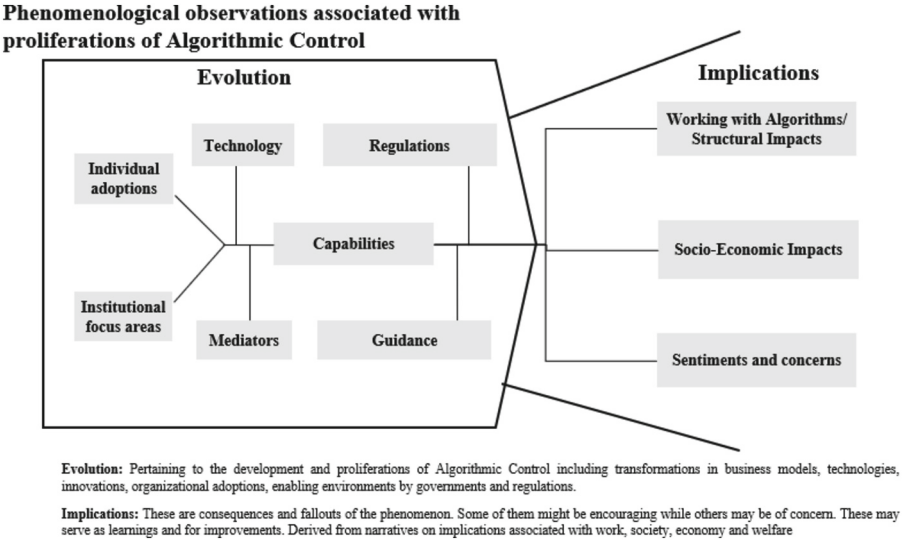

Fig. 2. A figure Nomological Network: Evolution and Implications from Micro-Meso-Macro Context.

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AI and Big Data Practices in Developing Country Context: A Socio-Technical Perspective

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Abstract. Advanced analytics, involving AI and big data, has radically transformed how firms capture value through enhanced business operations and product offerings. Nevertheless, firms often find initiating AI and big data projects much more manageable than maintaining them at scale during the post-adoption stage. This situation could be much more pronounced for developing nations due to their less sophisticated computing infrastructure, poor data quality, and constrained budgets. This study employs a qualitative approach to gain an in-depth understanding of the factors hindering post-adoption usage and scaling of AI and big data artifacts in a developing country context. We specifically present insights from ten experienced managerial and technical executives working across multiple industries. Based on the well-established socio-technical framework, our findings reveal sixteen challenges across four dimensions: structure, people, technology, and task. These factors highlight complexities in AI and big data practices in developing countries. Our research offers significant theoretical and practical implications.

Keywords: Analytics · Artificial Intelligence · Machine Learning · Post-adoption AI Scaling

1 Introduction

Most firms undertake advanced analytical initiatives like artificial intelligence (AI) and machine learning (ML) as proofs of concept (POCs), with a relatively lower proportion being pushed into full-scale production, thus limiting their ability to realize substantial business value [1]. This aspect tends to be much more pronounced in developing countries. For instance, evidence suggests that while 79% of Indian executives believe in leveraging AI and big data initiatives to achieve their growth objectives, most (~76%) struggle with enterprise-wide scaling [2]. Thus, addressing these discrepancies in perceived and realized performance becomes critical.

In particular, firms in developing countries tend to work with smaller-scale data, less advanced infrastructure, and constrained budgets [3]. Big tech firms like Google,

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Amazon, and Meta operate actively in these countries, resulting in limited opportunities for homegrown firms to harness the big data possibilities [3]. Moreover, it is relatively easier for these technology giants to hire high-quality tech talent from developing nations at efficient costs [4]. Remote hiring across underutilized regions has further intensified this trend. Hence, most local firms often find building a complete team of AI experts challenging. Furthermore, managers from these firms favor business strategies with assured and quicker returns [5]. Hence, they are sometimes skeptical of investing in the high-end, cost-intensive analytics tech that takes longer to mature. Considering these socio-technical complexities, we argue that analytics studies should not limit their theorization to firms with big data computing environments.

Previous research has predominantly studied AI and big data from the pre-adoption and adoption perspective [6–9]. However, the initial adoption of IT artifacts does not necessarily lead to their increased use levels in the post-adoption stages [10]. We expect complex technologies like AI and ML to follow a similar pattern. Unlike other IT investments, these technologies demand regular infusions of financial resources to maintain practical relevance [11]. Moreover, their unique characteristics, such as their ability to continuously learn from data without being explicitly programmed, render them with high implementation complexity [9]. Hence, more academic research is needed to understand factors hindering firms from post-adoption usage and scaling AI and big data artifacts [12]. Only a few studies have studied such challenges from low or medium-tech firms' context in developing countries. Wang et al. [13] utilized a case study to identify barriers to AI deployment in China's healthcare industry. Sharma et al. [14] explored challenges to AI implementation in India's public manufacturing sector. However, their study employed multi-criteria decision-making (MCDM) techniques to quantify experts' opinions on literature-driven factors. Still, a comprehensive investigation is lacking in identifying challenges for post-adoption usage and scaling AI and big data artifacts in developing nations. Thus, this study examines "what factors hinder the successful post-adoption usage and scaling of AI and big data artifacts by low-to-medium-tech firms in developing countries?" We use the well-established socio-technical theory (STT) to address this research question. As indicated, becoming analytics-driven is not merely a technical concern but also involves overcoming managerial challenges [3]. In this context, the STT approach encourages us to view the interaction between firms' social and technical subsystems.

2 Theoretical Background

2.1 Barriers to Scaling AI and Big Data Artifacts

The primary reasons for organizations' difficulty in successfully carrying out POCs into full-scale production are typically attributed to a need for more scalable data infrastructure, financial resources, skilled staff, and data governance [15]. Studies have also cited AI-specific concerns, like algorithmic opacity, model biases, and model drift, as potential challenges negatively influencing managers' trust in AI solutions [16, 17]. However, implementing AI and big data artifacts at a larger scale is more complex than technological aspects. It entails radical changes in organizational processes, culture, and mindset to capture the maximum value from these initiatives [18]. Likewise, Lee

et al. [19] identified thirteen barriers to AI implementation along four dimensions: organization, technology, IS, and people. However, their study predominantly employed a literature-driven approach to uncover these challenges.

Furthermore, most IS studies have studied AI and big data artifacts' scaling in developed economies context [17, 18, 20, 21]. While the technology appears to operate similarly in different nations, contextual and country-specific factors could significantly create variances in the post-adoption usage and scaling of these artifacts [22, 23]. However, very few studies have explored these challenges from a developing country context. Wang et al. [13] interviewed 22 clinicians from six rural clinics in Beijing and highlighted contextual, technical, usability, and trust-related concerns affecting AI-enabled clinical decision support systems' deployment. However, their research findings targeted a specific AI application in clinical decision-making, thus limiting their generalizability. Alshahrani et al. [23] found misalignments between managers and AI professionals, data integrity and sharing, linguistic and national-culture-related concerns, digital infrastructure, and governance and ethics as five critical barriers to AI assimilation. However, their study's scope was restricted to public sector firms. Few scholars used MCDM to assess the interrelationship among AI implementation challenges in India's public manufacturing sector [14]. Nevertheless, their study relied on a literature-driven piecemeal approach to identify challenges. Overall, the academic literature on post-adoption scaling of advanced analytics is relatively fragmented in developing country context. It, thus, calls for a broad qualitative approach to bring out technology's view as observed in practice [24].

2.2 Socio-Technical Theory

STT asserts that IS's successful implementation is part of a firm's technical and social subsystems [8]. Advanced analytical technologies have considerably altered how humans and technology interact, further reinforcing STT's relevance in today's contemporary business settings. In particular, the social subsystem consists of people and structure. 'People' relates to a firm's stakeholders, knowledge, and skills. 'Structure' refers to the organizational culture, norms, values, communication, and authority structure [25]. The technical subsystem also consists of two components. The first includes tools and infrastructure required to develop and scale AI and big data artifacts [8]. Its second component comprises tasks through which organizational objectives and stakeholders' needs are attained [26]. Previous work has validated STT in several contexts, including information technology [26] and AI adoption [8]. Consistent with the existing research, we apply the STT framework to explore challenges for scaling and post-adoption usage of AI and big data artifacts.

3 Methodology

We interviewed ten experts to explore factors hindering the usage and scaling of AI and big data artifacts in Indian firms in the post-adoption context. Table 1 describes the sample characteristics. We asked our respondents open-ended questions like: *What are the examples of AI and big data artifacts used in their organization? What challenges*

are encountered while implementing and scaling AI and big data artifacts? Why do data science projects have a higher perceived failure rate despite high accuracy during model development? We asked follow-up questions to gain an in-depth understanding of the deployment and scaling of advanced analytical initiatives. The interviews were mainly conducted over the telephone or Zoom and lasted an average of around 40 to 60 min. The interview data was obtained through voice recordings and later transcribed. Furthermore, we employed open and axial coding for data analysis and identification of themes [27].

Table 1. Demographic profile of interview respondents

Expert	Designation	Gender	Experience (in years)	Industry
R1	Chief Data & Analytics Officer	Male	17	Travel and tourism
R2	Chief Analytics Officer	Male	10	Management consulting
R3	Vice President	Male	14	Financial services
R4	Senior lead	Male	11	Financial services
R5	Manager, Analytics	Male	5.5	Management consulting
R6	Analytics Team Lead	Female	5	Management consulting
R7	Senior Data Scientist	Male	4	Financial services
R8	Analytics Manager	Male	6.5	Management consulting
R9	Senior Manager	Male	10	Management consulting
R10	Senior Data Scientist	Male	4.5	Manufacturing

4 Results

4.1 Social Subsystem (Structure)

Our analysis revealed sixteen challenges, as depicted in Table 2. Concerning the structural component, challenges were primarily identified in cultural, communication, and regulatory (legal and ethical) aspects. The most frequently stated challenge was the alignment issues between business and analytics teams. Our respondents explained how insufficient clarity about each other's domains often resulted in unrealistic expectations regarding the timeline, objectives, and scope of AI and big data projects: *"Let us say I am working on a linear regression or a time-series model. There will be some assumptions associated with these techniques. But, due to constrained deadlines, I might not have sufficient time to check if the data is stationary. I might build some ARIMA or moving average models and deliver the results. Generally, these results will not hold in real-life scenarios. It happens if the expectations are not set, and the culture is not mature with respect to data science" (R7).* Even if firms had access to a well-developed idea, data, skills, and computing power, it might not lead to successfully scaling AI artifacts. While

these components laid the foundation for advanced analytical initiatives, our respondents noted that AI was more exploratory than deterministic. They emphasized the need to consider the unsuccessful attempts in AI as learning opportunities. They also recommended using these learnings to support AI model iterations and fine-tuning parameters: *"ML relies heavily on patterns in data. But what if there are no patterns? What happens, then? Sometimes, we may spend months on an ML project and ultimately get nothing from it, and we should be ready to accept that" (R1).*

Concerning regulatory aspects, our findings revealed critical challenges related to secured data-sharing. Our respondents mentioned that failure to comply with data security policies resulted in serious penalty charges and reputational damage. Most respondents followed the European General Data Protection Regulations to ensure data security. Additionally, they explained that Indian firms were typically expected to store and process sensitive data within the nation's territories: *"One of the guidelines is that all Indian data will remain on Indian servers only. So, while we are using, processing or copying data, we must ensure that it is maintained on Indian servers" (R3).* Nevertheless, these guidelines necessitated companies to invest in local data centers, which was a cost-intensive exercise, contributing to the onerous compliance of Indian start-ups and homegrown firms [28]. As such, it presented a potential challenge for scaling AI and big data artifacts. Furthermore, since scaling often magnified ethical vulnerabilities, our respondents highlighted the criticality of being cautious while selecting variables during model development: *"For any of our marketing campaigns, we have to ensure we do not differentiate people in terms of their age, race, gender, socio-economic background, or even location" (R7).*

4.2 Social Subsystem (People)

One of the most critical challenges regarding the 'people' dimension was the shortage of high-quality AI skills, especially for homegrown firms. Our respondents noted that, in most cases, aspiring analytics professionals preferred data science as their career choice due to its popularity and monetary benefits. However, they often lacked an in-depth understanding of foundational statistical concepts that formed the basis for machine and deep learning. Concerns regarding appropriate soft skills like curiosity and willingness to learn were also raised: *"While interviewing, I have encountered several candidates who claim to know about applying neural networks. However, they are usually clueless when we ask simple statistical questions. How can one go deep into advanced analytics without knowing the basics?" (R6).*

Moreover, insufficient clarity about business requirements often resulted in an analytical model that was relatively less meaningful to the business, resulting in a substantial reduction in the post-adoption usage and scaling of AI and big data artifacts: *"If analytics teams do not understand what business wants and are just focused on the technology side of things, it may result in wrong decisions. For starters, firms may invest in the wrong platforms, which is a cost. They do get started on an AI initiative, but it just fades off at some point. They do not even make hard stops or put things on the back burner. They make many mistakes on the way and just run out of budget. That happens because companies are unsure if they require AI or ML" (R5).*

Neglecting issues such as overfitting, underfitting, data bias, and infrequent model retraining often resulted in variance in the model's perceived and realized performance. Such discrepancies in model performance during the development and production phases considerably diminished managers' trust in analytics solutions, thereby negatively influencing the possibilities for their subsequent scaling. Besides these concerns, our respondents observed that if business managers did not implement AI and big data recommendations as intended, explaining their contribution to managers became much more challenging. It ultimately led to reduced usage and scaling of the AI and big data artifacts. Furthermore, fragmentation within the value chain and changing business priorities also limited the post-adoption use of these artifacts: *"For one of our automobile clients, we created a propensity scoring model categorizing their potential website visitors into hot, warm, and cold leads. We completed and delivered the AI solution to them. However, the downstream systems that needed to consume this information to run campaigns and retarget their audience did not do the needful, and we have yet not realized the value of this particular use case" (R9).*

4.3 Technical Subsystem (Technology)

The most frequently cited challenge in the technology dimension was the need for scalable data infrastructure. Our respondents highlighted that the key obstacles in building scalable data infrastructure stemmed from high costs and the complexity of switching from legacy data environments: "*Many companies do not want to invest in new technologies and related infrastructure because it is a costly exercise. Primarily if things are running fine the old way, they let them function that way" (R4).*

Our interview findings revealed that AI infrastructure was one of the least mature components for most low-to-medium tech Indian firms: *"I worked with a global luxury automobile giant. We pitched several data-driven initiatives and ML use cases from their initial sales. However, the business executives were keen to work on ML use cases. So, we built and delivered the ML solutions. However, it is just sitting idle because their technological ecosystem is not yet ready to consume it" (R9).* A possible solution to overcome this challenge is combining AI and cloud computing. It enables firms to use the necessary infrastructure through the Internet and scale their AI and big data initiatives [29]. Our respondents informed us that most firms rely on tech giants to access AI cloud computing services. However, they noted that accessing these services was economically unviable, especially for small businesses and start-ups with insufficient data and resources. Another challenge highlighted by our respondents was the need for more high-quality data, especially in non-IT industries. Often, data was scattered and collected at different points in time. Hence, analytical professionals indicated the challenge of investing substantial efforts in integrating and cleaning datasets. Also, maintaining a corpus of sufficient positive and negative data points to train models was critical: *"The data has to be in such a way that the ML model can make some sense out of it. There has to be some pattern. That is how an ML model evolves, and most Indian companies do not have that kind of data" (R10).*

Our respondents indicated that a firm's inability to reconfigure and orchestrate resources could be a significant barrier to scaling AI and big data artifacts [30]. In this context, one of our respondents mentioned: *"There must be some mechanisms,*

some integration to ensure data flows. Activities like data import should be easily scheduled. If the system cannot automatically capture the incoming data, closing the feedback loop becomes challenging" (R8). Next, explainability issues were highlighted as another potential challenge, often leading to managers needing more trust in AI solutions, especially in industries with stricter regulations, like banking and healthcare: *"The interpretability becomes some bottleneck in the banking industry. If we implement anything above random forest or a non-linear model, we must explain it to the auditors. We must explain why we implemented these techniques and how the solution arrived" (R7).*

4.4 Technical Subsystem (Task)

The 'task' dimension is fulfilling organizational objectives and stakeholder requirements [25]. Thus, challenges in this cluster prevent firms from implementing AI and big data artifacts for strategic and economic reasons [26]. In this vein, our respondents explained how obtaining sponsors' approval was a critical challenge in scaling AI and big data artifacts. Generally, sponsoring stakeholders were unwilling to invest in advanced technologies unless they were convinced of getting an assured economic return: *"Until business managers do not feel that AI is an integral part of the system, they are unwilling to accept it. They are keen to look around for possibilities, but unless they find the ROI, they will not implement it" (R2).* Moreover, our respondents indicated that AI initiatives were typically ongoing and required constant infusion of resources to keep them relevant. Since huge upfront and recurring costs were often involved in building and maintaining AI artifacts, coupled with slow returns, most business managers were often discouraged from scaling these projects: *"Companies invest much in building AI/ML models but do not get the returns in time in AI/ML projects. If they invest now, they could reap its benefits five years later. This might not sit well with the managers trying to beat yearly or quarterly goals" (R9).*

Table 2. Factors hindering the successful post-adoption usage and scaling of advanced analytics initiatives by firms in developing nations

	Factors and their literature support	Description
Structure	Challenges in aligning the business and analytics views [3, 19, 20, 23, 30]	Disjointed expectations and motivational gaps between business and analytics teams often lead to AI and big data artifacts that are impractical to implement and scale
	Lack of a "test and learn" mindset [31]	The inability to view AI's exploratory nature hinders firms from experimenting and using those learnings for AI model iterations and parameter fine-tuning

(*continued*)

Table 2. (*continued*)

	Factors and their literature support	Description
	Costly compliance of legal framework on data privacy [14, 17, 23]	Firms invest substantial resources to comply with international laws and standards to ensure data privacy and security
	Fairness and bias considerations [9, 16, 19, 32]	It refers to organizations needing to invest substantial efforts during model development to mitigate emergent model bias
People	A critical shortage of high-quality AI and big data skills for homegrown firms (Our contribution)	Homegrown firms in India encounter significant constraints in recruiting highly-skilled tech talent, thus creating major roadblocks for scaling AI and big data artifacts
	Discrepancies in AI and big data artifacts' performance during the development and production phases [16, 17, 33, 34]	Neglecting overfitting, underfitting, data bias, and irregular training could result in models' perceived and realized performance variances. It results in managers lacking trust in analytical solutions and diminishing scaling possibilities
	AI and big data artifacts not being appropriately used by business stakeholders (Our contribution)	A firm's inability to use AI and big data artifacts appropriately could create challenges for analytics teams in explaining the contribution of these advanced analytical initiatives, thus negatively influencing their continued use and scaling opportunities
	Insufficient business and contextual understanding [3, 20, 34]	Insufficient clarity of business processes, operations, and requirements can often lead to building AI and big data artifacts that are impractical to implement and scale
Technology	Critical scarcity of scalable data infrastructure [14, 17]	Small-to-mid-sized firms lack appropriate data systems, servers, and networks that promote the sharing and consumption of data and information across the business, resulting in low scaling opportunities

(*continued*)

Table 2. (*continued*)

	Factors and their literature support	Description
	Dependency on global tech giants for AI Cloud computing services (Our contribution)	Most Indian firms rely on global tech giants for AI Cloud computing facilities. However, these services are expensive and could result in financial stress for small-to-mid-sized firms, hindering the successful scaling of AI and big data artifacts
	Poor data quality [14, 17, 19, 32]	Most organizations, especially from non-IT industries, lack access to meaningful and sufficiently representative data to build and train their AI and big data artifacts
	Inefficient systems integration and continuity [15, 18, 19]	Establishing seamless integration and interoperability between different technologies to support real-time information sharing and regular updating of AI and big data artifacts is a significant barrier for most firms
	Challenging to explain the working of AI and big data artifacts [16, 17, 19, 33, 35]	It refers to the inability of the analytics team to clearly articulate the working of the AI and big data artifacts to managers. It is sometimes due to AI algorithms' black-box nature
Task	Difficulty getting the buy-in from sponsoring stakeholders [30]	The analytics teams often find it challenging to get support from relevant business managers for advanced analytics proposals
	Lack of willingness for recurring AI and big data investment [7, 9, 19]	AI and big data initiatives require regular monetary infusions to hire and train people, upgrade data systems, and keep the models in working conditions. Most small-to-mid-sized businesses lack sufficient resources to undertake these tasks
	Unclear benefits from AI and big data artifacts [5, 9]	Delivering business impact from AI and big data initiatives typically takes longer than expected. It could negatively affect managers' expectations regarding the temporal and certainty aspects of attaining business value

5 Discussion

By interviewing experienced industry practitioners and utilizing the STT approach, this study identifies sixteen factors hindering the post-adoption scaling of AI and big data initiatives in a developing country context. As for the structural dimension, one of our key findings is the alignment issues between analytics and business teams. The disconnect between these teams often stems from the differences in their skill sets and is quite likely to be reflected in their thought processes [30]. Nevertheless, cultivating regular interaction could help bridge this disconnect [3, 6]. Our findings reinforce concepts around data randomness and experimentative culture [15, 31]. As indicated by our respondents, it encourages businesses to appreciate AI's exploratory nature and promote rapid trial of model iterations [18, 20]. Consistent with existing studies [16, 19, 23, 32], we found data security and ethical considerations to be prominent challenges. Particularly in the Indian context, we found data localization strategies as financially onerous for small businesses and start-ups.

Regarding the people-related dimension, this study presents two novel factors. A surprising finding is the critical shortage of AI skills for homegrown firms. Although India is among the top countries producing graduates with advanced tech skills [36], our findings highlight some pressing concerns. Despite the growing tech talent, our study indicates a critical shortage of expertise in basic statistical and foundational concepts in AI and ML, thus raising the urgency to address this challenge. In another finding, our study reveals that not using AI and big data artifacts' recommendations as intended could severely hamper their post-adoption usage and scaling possibilities. A potential reason could be that managers often find it challenging to shift from something they already know is working to AI's unpredictable nature. Hence, they are usually skeptical about directly applying the analytical recommendations.

Concerning the technological dimension, our findings indicate the critical scarcity of scalable data infrastructure as the primary reason for firms' inability to scale their AI and big data artifacts. This finding complements the extant IS studies since most small-to-mid-sized firms in developing nations lack sufficient financial resources to support their infrastructural needs [35]. At the same time, while larger organizations have sufficient resources, they are often discouraged by the complexities of switching from legacy environments [7]. Besides the much-discussed challenges related to explainability [16, 33, 35], poor data quality [14], and inefficient integration systems [18], our findings reveal a novel factor in this cluster: dependency on big tech giants for harnessing AI Cloud computing services. In particular, these servers are located outside India, which might contribute to network bandwidth and latency issues. It might introduce data security risks by storing sensitive data outside the nation's territories [29]. Also, hidden costs, like idle workloads, underprovisioning, and data migration costs, could raise small firms' complexity in maintaining cloud services [37]. Finally, our findings are consistent with extant IS research regarding the task dimension. Concurring with Ghobakhloo et al. [7], our findings highlight insufficient funds and hesitance toward recurring investment as crucial challenges. We also found long gestation issues and unclear benefits as potential barriers to AI scaling [5].

6 Contributions, Limitations, and Future Research Directions

This study offers the following contributions. First, it is an early attempt to explore barriers to post-adoption usage and scaling of AI and big data artifacts in a developing country context. Previous studies are predominantly restricted to discussing barriers and critical success factors in the AI adoption context [7–9]. By taking a post-adoption perspective, this study extends the existing literature in exploring challenges for maintaining the continued usage and enterprise-wide scaling of these initiatives. It is also the first study to utilize industry practitioner interviews to identify a comprehensive list of challenges associated with AI and big data artifacts' scaling and post-adoption usage in low-to-medium-tech Indian firms. Second, besides the prevailing views, this study reveals some novel challenges specific to the Indian context: dependency on big tech firms for AI cloud computing services and a critical shortage of AI-specific skills for homegrown firms. Additionally, our interview findings identify another novel concern of managers needing to use the AI recommendations as intended. Third, the current study presents sixteen factors that can be empirically assessed using conceptual models or MCDM techniques in future studies.

We present some interesting practical insights. First, business managers can use our findings to inform themselves of the potential challenges in scaling AI and big data artifacts. They can use these factors as a benchmark to assess areas for improvement. They can organize training to upskill their tech talent. Likewise, they can formulate ML governance guidelines to manage data quality, regulatory compliance, and end-to-end workflow of models. Second, considering the critical dearth of AI skills in developing nations, this study recommends that universities and ed-tech companies design their courses in alignment with industry requirements, mainly focusing on enhancing their students' core statistical knowledge.

Like any other research, there are a few limitations in this study. For instance, it utilizes cross-sectional data in its research approach. Future studies can conduct a longitudinal investigation to delve deeper into AI scaling challenges. While this study does not explore frontline users' viewpoints, including their perspectives could offer rich insights into post-adoption usage and scaling of analytical initiatives. Also, future studies could examine these challenges in the context of other developing countries to support our findings' generalizability.

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Generative AI for Healthcare Engineering and Technology Challenges

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Abstract. Healthcare field engineers play a critical role in ensuring the smooth operation and maintenance of medical equipment. However, they face numerous challenges such as adhering to standard operating procedures (SOPs), managing inventory, maintaining equipment quality, and optimizing time allocation. This research paper proposes a novel approach that harnesses the power of generative artificial intelligence (AI) to overcome these challenges. In this study, generative AI algorithms are employed to develop an intelligent system that assists healthcare field engineers in following SOPs accurately while being always compliant. This is aimed to ensure consistent and efficient procedures, leading to improved equipment performance and patient safety. Additionally, the system integrates generative AI techniques to uphold equipment quality. It transforms lengthy equipment manuals into interactive Q&A systems, enabling engineers to focus on their tasks and access key information as needed. This enhances engineer productivity and indirectly contributes to the equipment's working quality. While from a use case perspective, generative AI seems to effectively solve the problem of manually referring SOPs, compliance manuals and product catalogs. There would be technology challenges (especially around Artificial Intelligence) like data security, geo-political influences on data governance, dependency on specific technology platforms in addition to maintaining such systems over time effectively. In summary, this research introduces an innovative solution to address challenges faced by healthcare field engineers through the application of generative AI. By utilizing machine learning algorithms, the proposed system enhances adherence to standard operating procedures (SOPs), streamlines inventory management, improves equipment quality maintenance, and optimizes time management. The study's outcomes contribute to the efficient implementation of SOP adherence and process guidelines, while also providing guidelines to tackle long-term challenges related to technology maintenance, ethical compliance of AI systems, mitigation of risks and data governance influenced by the dynamic geopolitical landscape.

Keywords: Artificial Intelligence · Generative AI · LLM · NLP · Healthcare · Maintenance · Standard Procedures · Compliance · Data Governance · AI Bias

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1 Introduction

Healthcare field engineers face challenges in adhering to SOPs, managing inventory, maintaining equipment quality, and optimizing time allocation. These challenges can impact operational efficiency and patient safety. To address these issues, this research paper introduces a novel approach that utilizes generative AI to enhance the capabilities of healthcare field engineers.

The proposed system employs generative AI algorithms to generate optimized SOPs based on specific equipment types and maintenance requirements. It streamlines inventory management, automates procurement processes, and reduces equipment downtime. Additionally, the system monitors equipment performance indicators to proactively maintain quality and predict potential failures. Furthermore, it optimizes time allocation by generating efficient schedules and routes for field engineers.

Through a comprehensive evaluation framework, the effectiveness of the proposed approach is validated using real-world data. By improving SOP adherence, inventory management, equipment quality, and time allocation, this research aims to enhance operational efficiency and quality in healthcare equipment management.

2 Healthcare Engineering Process - A Snapshot

The field services process in the Healthcare (medical devices industry) involves providing technical support (remote as well as on-site), maintenance, and repair/swap of components, here is a general snapshot of the process.

Service Request: The process typically begins with a service request from a healthcare facility or a customer who needs assistance with a medical device. The request is generally made through an existing toll-free number which is later directly connected to a technical support person for quick online support for instant troubleshooting (Level I support L1).

Logging and Dispatch: The service request is logged into a system and relevant information such as device details, customer info, and the nature of the problem are recorded with comments from Level I support if the problem is not resolved by L1 support then it is assigned to field service engineer based on their availability, expertise, and proximity to the customer location.

Level II Support and Further Scheduling: Basis to call allocation Field Service Engineer further troubleshoots the problem and gathers in-depth information to resolve the issue. Basis to this action if the issue is not resolved, Engineer plans his travel, orders spare (if required), and keeps the customer informed about the backend activities which include spares status, ETA for spares, and downtime of equipment.

On-Site Visit (Troubleshooting & Repair/Swap): The Field Service Engineer visits the customer site along with necessary tools and spares and applies his/her technical skills further to examine the device, identify the problem, and perform troubleshooting to diagnose the root cause. They may use specialized diagnostic equipment, software, or test procedures to identify and resolve the issue. If a repair is required, they may replace faulty components or perform adjustments to restore the device's functionality.

Escalation and Support (Level III or Level IV): In cases where the field service team is unable to resolve the issue on-site, they may escalate the problem to higher-level technical support or engineering teams. These teams can provide additional expertise and guidance to resolve complex or critical issues.

Documentation and Reporting: During the service visit, the field service engineer maintains detailed records of the work performed, parts replaced, and any recommendations or observations made. These records are essential for documentation purposes, warranty claims, and future reference. Throughout the field services process, effective communication, proper documentation, adherence to quality standards, and compliance with regulatory requirements are essential to ensure the smooth functioning of medical devices and customer satisfaction.

Each task requires a thorough manual documentation review, typically available digitally on the company's employee portal. However, locating the right information within the correct context can be challenging and error-prone, potentially leading to regulatory non-compliance and reduced trust in healthcare equipment.

Moreover, the growing biomedical industry and a shortage of skilled engineers are expected to exacerbate this issue.

3 Industry Demand and Outlook

Global Market Size: The global medical devices market size was valued at $512.29 billion in 2022 & is projected to grow from $536.12 billion in 2023 to $799.67 billion by 2030 [1]. The market share is further augmented by increasing R&D investments by the leading market players to develop technologically advanced equipment, with an aim to cater to the growing demand for innovative devices.

Supply of Qualified Field Engineers: The availability of qualified field engineers is crucial for the medical devices service industry. These professionals are responsible for installation, maintenance, repairs, and technical support. With the increasing complexity of medical devices, there is a growing need for highly skilled engineers who possess a deep understanding of both the technology and the healthcare environment. In US alone, there were ~18000 healthcare engineers at work, with need for healthcare engineers expected to grow at 10% CAGR for next 10 years [2]

Skill Gap Analysis: While there is no independent research in this area but based on once of co-author's experience in the field of healthcare engineering, the gap between engineer's knowledge and skills needed for maintaining the critical healthcare equipment is glaringly visible. In this scenario, there is a need to systems which can provide much needed assistance to the healthcare engineers.

4 Future Trends in Healthcare Engineering and Maintenance

Several trends are shaping the future of the medical device service industry are not compatible with existing manual methods of interacting with equipment documentation. These trends include:

Remote Support and Monitoring: The adoption of remote support and monitoring capabilities allows for real-time troubleshooting, proactive maintenance, and data-driven insights. This trend is expected to continue as connected devices and IoT technologies advance.

Predictive Maintenance: Predictive maintenance uses data analytics and machine learning algorithms to identify potential issues before they occur, enabling proactive maintenance. This trend helps optimize device performance, minimize downtime, and reduce costs [3].

Value-Added Services: Medical device service providers are increasingly offering value-added services, such as training programs, data analytics, and consulting services. This diversification allows companies to differentiate themselves and provide comprehensive solutions to customers.

Focus on Patient-Centric Care: The industry is shifting toward a more patient-centric approach, emphasizing improved patient outcomes, personalized care, and patient satisfaction. Medical device services will align with this trend by incorporating patient engagement tools, remote monitoring, and patient education resources.

5 Healthcare Engineer's Challenges

Complex and Evolving Technology: Medical devices are becoming increasingly sophisticated, incorporating advanced technology, software, and connectivity features. Field service engineers need to stay updated with the latest advancements and continually upgrade their technical skills to effectively troubleshoot and repair these complex devices.

Time Constraints: In healthcare settings, medical devices are critical for patient care, and any downtime can have serious implications. Field service engineers often face time pressure to quickly diagnose and repair devices to minimize disruption to healthcare operations and patient care.

Regulatory Compliance: Medical devices are subject to strict regulatory requirements, such as those imposed by the Food and Drug Administration (FDA) in the United States and similar agencies worldwide. Field service engineers must ensure compliance with regulations while performing repairs, maintenance, and software updates [4].

Troubleshooting Complex Issues: Healthcare engineers encounter a wide range of device malfunctions, ranging from simple hardware failures to complex software glitches. They must possess strong troubleshooting skills to identify the root cause of the problem accurately and efficiently.

Safety Considerations: Medical devices directly impact patient safety and well-being. Healthcare engineers must follow proper safety protocols while working on medical equipment to prevent any potential harm to patients or themselves. They need to be aware of infection control procedures, electrical safety measures, and other safety guidelines specific to healthcare settings [5].

Customer Interactions: Healthcare engineers often interact directly with healthcare professionals, including doctors, nurses, and technicians. Compliance, process, and impact on patient health are crucial factors to understand and effectively communicate for ensuring a positive customer experience.

Documentation and Reporting: Accurate and detailed documentation of service activities, including repairs, parts replaced, and troubleshooting steps, is essential for compliance, warranty claims, and future reference. Field service engineers must maintain comprehensive records while balancing the demands of their work.

Multitasking: Field Service Engineer has to work under constant pressure situations, as one person is responsible for multiple equipment/customers, and this varies based on equipment type and criticality. This leads to extreme time-based planning to ensure each customer issue is attended to on time and the patient is treated properly.

Considering all the above listed challenges, presence of skill gap, growing demand of healthcare engineers, work pressure and most importantly the overall impact their work creates on healthcare industry, it's imperative to have productivity and quality enhancing solutions.

6 Solution – Generative Artificial Intelligence

While Generative AI offers a wide range of possibilities including text, image and video, our study for the use case would be limited to text-based interactions.

Currently Enterprises are leveraging large language models like GPT4 for their ability to communicate complex ideas concisely. However, it is known that these LLMs are limited by the information they are trained on, which is publicly available. To further make it meaningful, organizations are exploring at ways to augment with enterprise data.

In today's volatile environment, enterprises need to leverage their proprietary knowledge to compete and innovate. However, knowledge is often siloed and difficult to access. This can hinder innovation and prevent companies from realizing their full potential. Generative AI models offer new opportunities for knowledge management, which can enhance company performance, learning, and innovation, helping increase productivity, improved retention, and higher customer satisfaction.

More and more organizations are using large language models (LLMs) to capture and share their intellectual capital. This includes informing customer-facing employees about company policy and product recommendations, solving customer service problems, and so on.

For our problem statement summarized above, we would be leveraging on Generative AI by using Large Language Models (LLMs).

6.1 Framework for Picking the Right Generative AI Project

LLMs like GPT-4 have created hype and speculation. ChatGPT reached 100 million users in two months, the fastest ever. However, there are many other evolving LLMs and our solution approach is LLM agnostic.

Harvard Business Review [6] recently published a very easy to understand matrix, which helps us meaningfully evaluate, which use-case is fit for Generative AI and with what element of risk. When considering the exploration of generative AI, an enterprise should weigh risk and demand. Two essential questions to ask are: "How harmful would it be if false information and inaccuracies were generated and spread?" (Risk) and "What is the genuine and lasting demand for this type of output, beyond the current hype?" (Demand) (Fig. 1).

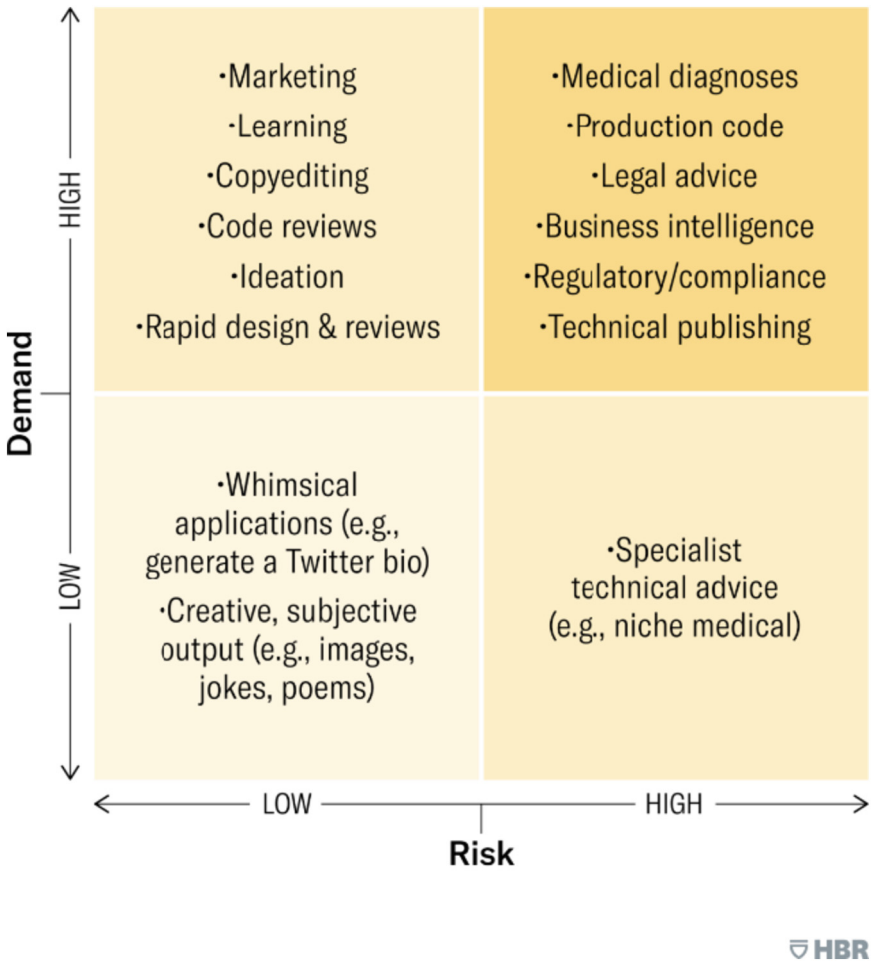

Fig. 1. Generative AI Risk-Demand Matrix

As per this matrix, our use case qualifies as a high-demand and high-risk project. To mitigate the risk and enhance the efficacy of the solution; our approach is to feed indexed enterprise data, which will assist Generative AI engine to be more accurate

6.2 Evaluation of Potential Approaches [7]

a. *Training an LLM from Scratch*: Creating and training a domain-specific model from scratch is not a recommended approach because it requires a massive amount of data, computing power, and technology talent. Most companies do not have these resources.
b. *Fine-Tuning existing LLM*: Another approach is to fine-tune an existing LLM to add specific domain content. This involves adjusting the parameters of the model to make it more specialized for the specific domain. This approach requires less data and computing power than creating a new model from scratch.
c. *Prompt Engineering an Existing LLM*: The most common approach for enterprises to customize the content of an LLM is to prompt tune it. This involves keeping the original model frozen and modifying it with prompts that contain domain-specific knowledge. After prompt tuning, the model can answer questions related to that knowledge. This approach is the most computationally efficient and does not require a large amount of data.

For our goal to increase the productivity of healthcare engineers and enhance the quality of healthcare devices infrastructure, second approach fits the best.

6.3 Solution Approach

The following diagram shows a high-level architecture of the proposed Generative AI solution (Fig. 2).

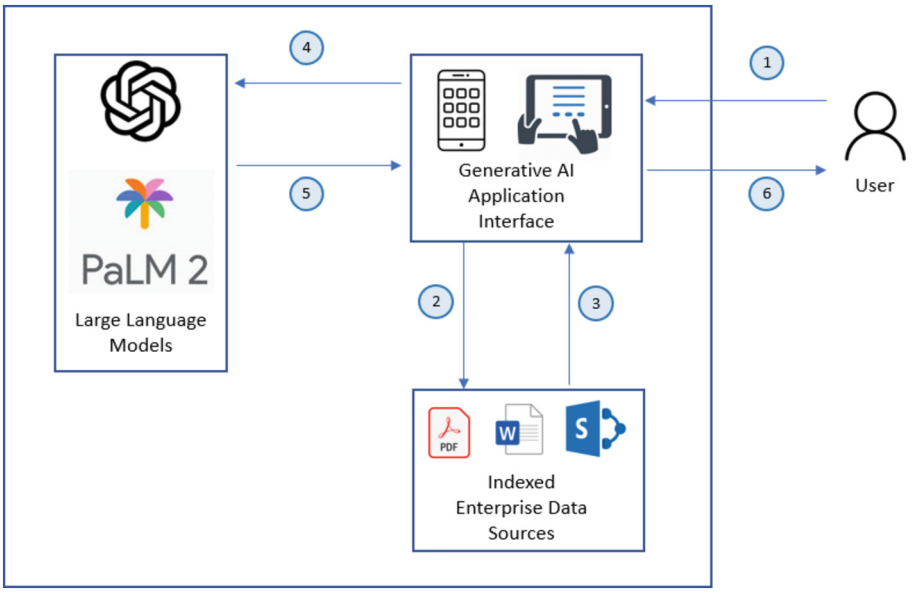

Fig. 2. High Level Architecture of the proposed Generative AI Solution

When a user engages with the GenAI app, the following sequence occurs:

1. The user makes a request to Gen AI application.
2. The app uses a search query to file index. This indexing helps us reduce risks by enhancing the accuracy of the outcomes.
3. The index returns search results with excerpts of relevant documents from the ingested enterprise data.
4. The app sends the user request and long with the data retrieved from the index as context in the LLM prompt.
5. The LLM returns a succinct response to the user request based on the retrieved data.
6. The response from the LLM is sent back to the user.

This architecture is LLM agnostic, hence could be easily extended to wide range of LLMs like OpenAI's GPT-4, Google's PaLM 2, Hugging Face, AI21 Labs, Cohere, and others.

To achieve optimal outcomes, a GenAI app must tailor the prompt according to the user's request and the Language Model (LLM) employed. Additionally, conversational AI apps must effectively handle chat history and maintain context. Developers of GenAI apps can leverage open-source frameworks like LangChain, which offer modules for seamless integration with their preferred LLM, as well as orchestration tools for activities like managing chat history and engineering prompts.

6.4 Technology Platform

There exists, many known platforms like Azure, Google Vertex, C3.ai etc,, our preferred platform is Amazon due to it's ease of implementation and Sagemaker's known capabilities. However, the proposed solution framework is extensible to all the platforms as well. Below is the Amazon Web Services' architecture for "Fine-tuning LLM" approach of implementing a Generative AI Solution [8] (Fig. 3).

The above architecture cum technology workflow includes the following steps.

1. The enterprise documents are stored on Amazon S3 and ingested to an Amazon Kendra index using the S3 data source connector.
2. The LLM is hosted on a SageMaker endpoint.
3. An Amazon Lex chatbot is used to interact with the user via the Amazon Lex web UI.
4. The solution uses an AWS Lambda function with LangChain to orchestrate between Amazon Kendra, Amazon Lex, and the LLM.
5. When users ask the Amazon Lex chatbot for answers from an enterprise document, Amazon Lex calls the LangChain orchestrator to fulfill the request.
6. Based on the query, the LangChain orchestrator pulls the relevant records and paragraphs from Amazon Kendra.
7. The LangChain orchestrator provides these relevant records to the LLM along with the query and relevant prompt to carry out the required activity.
8. The LLM processes the request from the LangChain orchestrator and returns the result.
9. The LangChain orchestrator gets the result from the LLM and sends it to the end-user through the Amazon Lex chatbot.

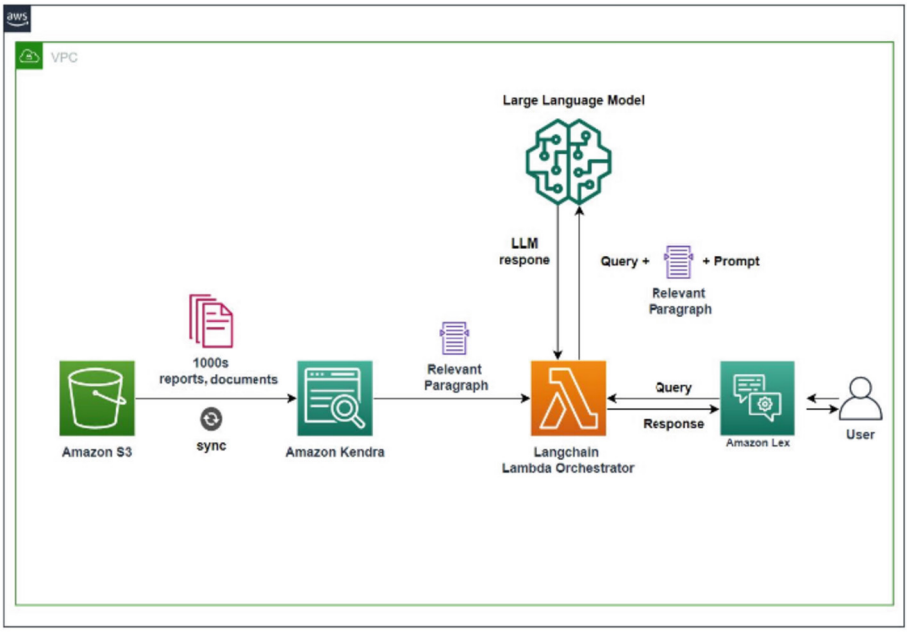

Fig. 3. Technology Architecture cum Workflow

We performed a Proof of concept on this platform and below is a summary of key outcomes.

1. *Data Privacy and Security:* The LLM is housed within the Virtual Private Cloud (VPC), ensuring that the inputs we feed into the LLM remain within the confines of the solution infrastructure, granting full control over sensitive data.
2. *Time required to develop the solution:* The proposed solution can be developed in 6–9 months with a small IT team of 7–10 members.
3. *Expected System Maintenance:* Maintaining the document repository (product catalogs, SOP documents, etc.) is easy. However, due to the AI nature of the system, ongoing monitoring for model drift requires a dedicated team of data scientists. Additionally, continuous prompt engineering for LLMs is necessary to maintain a control over responses over time.

6.5 Challenges with Enterprise AI Solutions (Including Generative AI)

1. *Handling Bias:* The issue of bias in Artificial Intelligence is a real concern that requires specific attention, considering that if human intelligence can be biased, so can AI. Bias refers to the systematic and unfair favoritism or discrimination towards certain groups or individuals based on their characteristics such as race, gender, or socioeconomic status [9]. Since generative AI models are trained on large datasets, they can inadvertently learn biases present in the data, leading to biased outputs. Handling bias in generative AI is a challenging task, but here are some approaches that can help mitigate it:

a. High quality training data: Using diverse and representative training data is crucial to reduce bias. Careful curation of the dataset can help minimize the presence of biased patterns and ensure a more balanced representation of different groups.
b. Pre-processing and data augmentation: Applying preprocessing techniques such as data augmentation, data cleaning, and anonymization can help mitigate biases. These techniques can remove or reduce identifying information that may contribute to bias.
c. Human in the loop: Incorporating a Human in the Loop (HITL) approach is crucial for generative AI systems. Despite their impressive capabilities, these systems often lack context, ethics, and real-world understanding. Human involvement bridges these gaps, ensuring responsible and meaningful outputs. HITL leverages human expertise to refine and validate AI-generated content, enhancing accuracy, relevance, and alignment with human values. This collaboration fosters trust, transparency, and minimizes risks of uncontrolled and biased generation. Including humans in the loop maximizes the potential of generative AI while mitigating challenges and maximizing beneficial impact.

2. *Lack of risk frameworks for AI systems:* Despite efforts, universally available and comprehensive risk frameworks for AI systems remain lacking. AI ethics and risk assessment are relatively new fields, and the fast-paced advancement of AI technology presents challenges in addressing potential risks. Reasons for the current lack of availability include:
   a. *Evolving nature of AI systems*: AI's rapid evolution hampers the development of static risk frameworks. Constant emergence of new techniques, applications, and risks necessitates ongoing research for evolving risk frameworks.
   b. *Complexity and interdisciplinary nature*: Developing comprehensive risk frameworks for AI systems is challenging due to the complex interactions between algorithms, data, and human factors. Achieving interdisciplinary collaboration and expertise on a global scale is difficult to address technical, ethical, legal, and societal dimensions.
   c. *Industry-specific considerations*: Risk frameworks must consider specific AI system contexts and applications. Risks in one domain may not be applicable elsewhere. Tailoring frameworks to diverse industries, sectors, and societal contexts is complex.
   d. *Lack of consensus and standardization*: Consensus and standardization on AI risk frameworks are lacking. Varying perspectives among organizations, countries, and stakeholders on risk definition and mitigation require gradual harmonization.

While the above risks and their mitigation strategies continue to evolve; during our proof of concept, we observed the proposed solution demonstrated good maturity levels in handling these. But there needs to be a continuous focus on these aspects.

3. *Impact of Geo-political landscape on AI systems:* Geopolitics can impact AI systems in various ways [10]:
   a. Data access and localization can be influenced by cross-border data restrictions, affecting data availability for AI training.
   b. Technology competition and innovation can be shaped by geopolitical rivalries, impacting AI research and development.

c. Ethical and regulatory frameworks vary across regions, posing challenges for deploying AI systems globally.

To handle these uncertainties, having a flexible and extensible solution is important. The proposed solution is cloud based and can be transformed into a sovereign cloud infrastructure.

7 Industrialization of the Solution

Now that we have examined the proposed solution, our next step is to explore a more in-depth approach to its industrialization.

Input Data Procurement: The biomedical equipment manufacturer has a well-organized collection of documents that include manuals, standard procedures, and troubleshooting guides. These documents are the main source of data for our proposed Generative AI solution. Additionally, we can also include data from the company's databases, which keep track of inventory, machinery maintenance, and the performance of healthcare facilities. This will provide a comprehensive advisory resource for healthcare engineers.

Data Pipelines and Integration: In the proof-of-concept phase, we directly uploaded the documents to Amazon S3 buckets. However, for the industrialization phase, we propose to develop a portal that enables business leaders to upload documents and manage connectivity with enterprise databases.

Training and Deployment: After engineering the solution, the generative AI system must undergo training through input data synthesis. While document training is automated, integrating enterprise databases will necessitate the involvement of AI engineering teams.

Validation: After deploying the solution in Quality Assurance mode, all stakeholders must rigorously utilize the system, assess its accuracy, and establish guidelines for its practical application. To further enhance the accuracy, prompt engineering is recommended.

Phased Implementation: To begin with, we recommend a limited geographical roll-out of the solution, possibly in an area with a high concentration of diverse machine deployments. This approach allows for the quantification of critical metrics such as productivity gains, user experience, and outcome accuracy. Any identified issues can be promptly localized and addressed in a controlled fashion. Once this pilot implementation is successful then this can be rolled-out across larger geography and user base.

Healthcare Regulation Compliance: Although the AWS-based solution we propose inherently complies with GDPR and HIPAA standards, we are confident in our compliance with regulations due to our limited scope of operations, focusing solely on technical information and product manuals of biomedical machines, without any involvement of PII (Personally Identifiable Information) or PHI (Patient Health Information)

Explicability: LLMs are deep neural networks and aren't inherently explicable. But for enterprise AI applications, explicability is an important aspect. System must be able to explain the reasoning behind generating certain output [11]. While industrializing the proposed solution, procedures like LIME (Local Interpretable Model-Agnostic Explanations) [12] or SHAP (SHapley Additive exPlanations) is recommended.

The To-Be Process (After Solution Deployment)

a. The healthcare engineer would login to a portal/mobile app powered by the above discussed Generative AI solution.
b. The engineer requests specific information in a manner like ChatGPT/Bard, specifically within the context of healthcare engineering services.
c. The Generative AI solution would interact with pre-trained documents and integrated systems to collect, collate, and produce comprehensive information. Human-in-the-loop verification would be augmented by document references.
d. All these question and answers would be digitally persisted, for future analysis thus also offering traceability of events.
e. The system will also prompt engineers to input reconciliation information into the enterprise system, ensuring synchronization across all systems.

8 Conclusion

In conclusion, this research not only presents a solution to overcome the challenges encountered by healthcare field engineers but also presents a generalized view of how similar problems can be solved through the application of generative AI. By leveraging generative AI algorithms, the proposed intelligent system is expected to enable adherence to standard operating procedures (SOPs) while ensuring compliance. This is expected to make procedures consistent and efficient, resulting in improved equipment performance and enhanced patient safety. Furthermore, the system is expected to enhance the productivity and work experience of healthcare engineers by transforming lengthy equipment manuals into interactive Q&A systems. While generative AI demonstrates effectiveness in addressing the challenges related to SOPs and compliance, it is important to acknowledge the technology challenges such as data security, geopolitical influences on data governance, and the need for long-term maintenance and ethical compliance. There is also a need to have a pragmatic view towards adoption of novel technologies like Generative AI. Thorough evaluation of risks, long term enterprise goals, their roadmap and choosing right composable technology platforms (to reduce dependency) are business critical for successful achievement of business goals.

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Responsible Adoption of Artificial Intelligence in Agriculture: Ensuring Ethical, Transparent, and Sustainable Outcomes

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Abstract. Integrating Artificial Intelligence (AI) in agriculture holds great promise for optimizing resource utilization, improving crop yields, and promoting sustainable practices. However, the responsible adoption of AI in agriculture is critical to addressing ethical challenges, ensuring Transparency, and avoiding unintended negative consequences. The responsible adoption of AI in agriculture entails a conscientious and ethical approach to integrating AI into farming practices. This research explores Ethical concerns, Transparency, and Sustainable resource management by proposing a novel ETS framework for the responsible adoption of AI in agriculture and a case study of its application to achieve this objective. This framework can be a helpful tool to maximize the benefits of technology while safeguarding ethical, transparent, and sustainable outcomes for all stakeholders and the environment.

Keywords: Responsible Adoption · Agriculture · AI · Transparency · Ethics · Sustainability · Data Security

1 Introduction

Artificial Intelligence (AI) has transformed modern agriculture, which has helped create sustainable and efficient systems. AI technologies like machine learning, computer vision, and data analytics give farmers and agribusinesses data-driven insights, automation, and optimization. Responsible adoption of AI in agriculture requires ethical and diligent implementation. It requires fairness, accountability, and transparency while optimizing resource utilization and minimizing environmental effects. Transparency helps farmers, regulators, and consumers understand AI systems and their decisions. Agriculture must avoid digital barriers by maintaining equitable access. Responsible adoption of AI in agriculture maximizes technology benefits while ensuring ethical, transparent, and sustainable outcomes for stakeholders and the environment.

AI has the potential to transform agriculture, enabling efficient and sustainable food production. Precision agriculture is a vital AI application in modern

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farming [9]. AI monitors crop health and detects diseases and pests in real-time using computer vision and image recognition [18]. AI-powered models estimate agricultural yields, weather patterns, and market trends using historical and real-time data [13,17]. Autonomous tractors, harvesters, and robotic arms can reduce labor costs and boost productivity by performing precision planting, weeding, and harvesting [2,3]. AI technologies assess soil data and suggest tailor-made nutrient management plans for individual field circumstances [32]. AI models consider climate data and provide timely advice for farmers to implement climate-resilient practices [16]. AI improves supply chain efficiency, reducing food waste and boosting food security [14].

Responsible adoption of AI promotes sustainable agriculture and reduces environmental impact [30]. This adoption guarantees that analytics data meets privacy and security laws, promoting stakeholder trust [1]. For ecological balance, this adoption stresses non-toxic, ecologically acceptable management mechanisms. Data analysis and practical insights for adapting to changing environmental conditions support climate-smart practices [4]. Finally, it supports smallholder farmers and local communities by spreading resources.

By keeping this in mind, this paper introduces a novel ETS framework (see Fig. 1). Section 2 covers ethical considerations, whereas Sect. 3 covers AI transparency in agriculture, and Sect. 4 covers AI for sustainable resource management. Section 5 outlines a case study for applying the proposed framework.

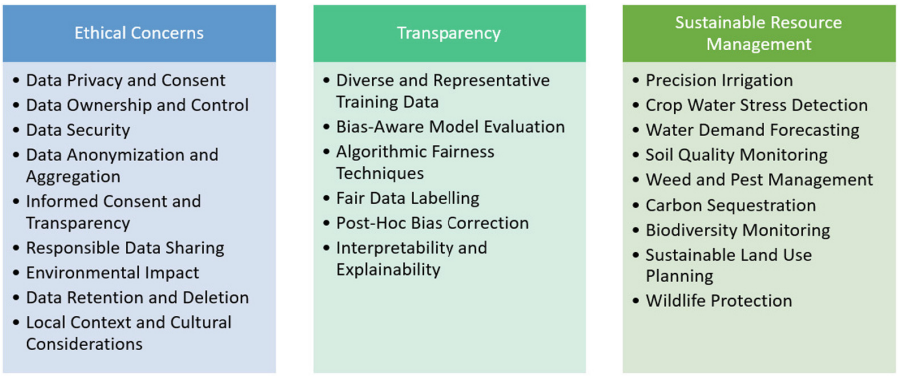

Fig. 1. Proposed ETS Framework designed for responsible adoption of AI in Agriculture for ensuring Ethical, Transparent, and Sustainable outcomes.

2 Ethical Concerns in AI Agricultural Data Management

Adopting AI in agriculture brings several ethical considerations related to data management. Ensuring data privacy, security, and fair use are essential to building trust and maintaining responsible AI practices in the agricultural sector. Here are some key ethical considerations:

- **Data Privacy and Consent:** Collecting and using agricultural data must respect farmers' privacy rights. AI systems should obtain explicit consent from farmers before accessing and using their data for analysis or decision-making processes [22].
- **Data Ownership and Control:** Farmers should have control over their data and be informed about how it will be used. Ethical data management practices involve giving farmers the right to decide who can access their data and for what purposes [8].
- **Data Security:** AI systems should protect agricultural data from unauthorized access, tampering, or theft. Robust security measures must be implemented to safeguard sensitive information [20].
- **Data Anonymization and Aggregation:** Aggregating and anonymizing data can help protect individual farmers' identities while enabling valuable insights. Ethical AI data management minimizes the risk of re-identification and ensures data anonymity [11].
- **Informed Consent and Transparency:** Farmers should be well-informed about how their data will be used and the potential implications of AI-based decisions. Ethical data management practices promote transparency and explain AI processes clearly to build trust [6].
- **Responsible Data Sharing:** AI data management in agriculture should adhere to responsible data-sharing practices. Sharing data with appropriate safeguards and in line with data-sharing agreements is crucial to promote collaboration and knowledge-sharing while protecting individual farmers' interests [6].
- **Environmental Impact:** Ethical data management also considers the environmental impact of data storage and processing. AI systems should aim to be energy-efficient and environmentally responsible in managing large datasets [33].
- **Data Retention and Deletion:** AI systems should only retain data for as long as necessary. Ethical data management includes appropriate retention policies and secure data deletion when no longer needed [4].
- **Local Context and Cultural Considerations:** Ethical AI data management considers the local context and cultural sensitivities. Data collection and use should respect cultural norms and align with the communities' values [1].

3 Transparency in AI Algorithms Applied to Agriculture

AI models are not immune to biases, which can lead to unfair and discriminatory outcomes. Identifying and mitigating biases in AI models is crucial to ensure equitable and responsible use of AI technologies in agriculture.

There are three possible types of biases in AI models: Data Bias [7], Algorithmic Bias [27] and Labeling Bias [34]. Identifying and mitigating biases in AI models used in agriculture is essential to foster equitable and responsible adoption of AI. These biases can be mitigated as follows:

- **Diverse and Representative Training Data:** Ensuring that training agriculture data is diverse and representative of the target population can help mitigate biases. Data augmentation techniques and active efforts to include underrepresented groups can improve model fairness [31].
- **Bias-Aware Model Evaluation:** Developing evaluation metrics that explicitly measure bias in AI models built on agriculture data can help identify and address biases. Metrics such as fairness-aware accuracy and demographic parity can assist in assessing model fairness [10].
- **Algorithmic Fairness Techniques:** Researchers have proposed various algorithmic fairness techniques built for agriculture data, such as reweighting training samples, adding fairness constraints during model training, and adjusting decision thresholds to achieve fairer outcomes [21].
- **Fair Data Labeling:** Implementing fair data labeling processes of agriculture data, including multiple annotator checks and guidelines, can reduce labeling biases and ensure the fairness of labeled data.
- **Post-Hoc Bias Correction:** Applying Post-Hoc bias correction techniques on agriculture data can help adjust predictions to align with fairness criteria. These techniques aim to equalize prediction outcomes across different demographic groups [5].
- **Interpretability and Explainability:** Incorporating interpretability and explainability into AI models built upon agriculture data can help identify and understand biases. Transparent models allow stakeholders to assess how biases might impact decisions [28].

4 AI for Sustainable Resource Management

AI-based solutions are crucial in water conservation, soil health improvement, and ecosystem preservation in agriculture. By harnessing the power of AI using data-driven insights to optimize resource management and support sustainable practices, stakeholders can work towards more resilient and environmentally friendly agricultural systems.

AI-driven solutions offer innovative ways to conserve water in agriculture:

- **Precision Irrigation:** AI technologies analyze real-time data from soil sensors, weather forecasts, and crop needs to optimize irrigation schedules. This analysis enables farmers to deliver water precisely when and where crops need it, reducing water wastage [30].
- **Crop Water Stress Detection:** AI-powered drones with thermal and multispectral cameras can identify water-stressed crops. Early detection allows for targeted intervention, ensuring efficient water use [12].
- **Water Demand Forecasting:** AI models analyze historical data to predict water demand for agriculture. This analysis helps water authorities plan for irrigation needs and balance water allocation [26].

Similarly, AI-based solutions contribute to preserving soil health and sustainability:

- **Soil Quality Monitoring:** AI systems analyze soil samples to assess nutrient levels, organic matter content, and soil health indicators. This data guides farmers in precise nutrient management and conservation practices [24].
- **Weed and Pest Management:** AI-driven computer vision enables early detection of weeds and pests. This facility allows targeted interventions, minimizing the need for chemical applications and reducing environmental impact [25].
- **Carbon Sequestration:** AI models can estimate carbon sequestration potential in soils, encouraging practices that enhance carbon storage and promote sustainable land management [23].

Finally, AI solutions contribute to preserving Biodiversity and ecosystem balance:

- **Biodiversity Monitoring:** AI-powered image recognition systems can identify plant and animal species, aiding Biodiversity monitoring and conservation efforts [29].
- **Sustainable Land Use Planning:** AI models analyze geospatial data to support land use planning that minimizes deforestation and land degradation, preserving natural ecosystems [19].
- **Wildlife Protection:** AI-enabled cameras and sensors help detect illegal activities and poaching, assisting in wildlife protection and enforcement efforts [15].

5 Case Study: Responsible Adoption of AI in Telangana's Agriculture Sector

5.1 Background

Telangana, a predominantly agrarian state in southern India, recognized the potential of AI to revolutionize its agriculture sector while upholding ethical, transparent, and sustainable practices. It launched the World Economic Forum's Artificial Intelligence for Agricultural Innovation (AI4AI) program with the aim of establishing the frameworks through which emerging technology solutions can be scaled up across the agriculture ecosystem (https://www3.weforum.org/docs/WEF_Artificial_Intelligence_for_Agriculture_Innovation_2021.pdf). Facing challenges related to water scarcity and resource optimization, the state embarked on an ambitious journey to integrate AI into agriculture responsibly.

5.2 Initiative

In collaboration with industry, academia, startup community, and civil society, Telangana initiated a comprehensive program aimed at ensuring ethical, transparent, and sustainable outcomes in agriculture through AI adoption as part of AI Strategy for Telangana (https://it.telangana.gov.in/minister-ktr-launches-artificial-intelligence-for-agricultural-innovation-ai4ai-program/).

5.3 Implementation

For achieving the better outcomes, the stakeholders can adopt the proposed framework as follows:

- **Data-Driven Insights:** The initiative can involve deploying IoT sensors, drones, and satellites to collect extensive data on soil conditions, weather patterns, and crop health across the state. This data formed the foundation for AI-driven insights.
- **Ethical AI Framework:** To maintain ethical standards, AI algorithms should undergo rigorous testing and auditing to eliminate bias. Transparent decision-making processes can ensure that farmers understand how AI-driven recommendations are getting generated.
- **Farmers' Empowerment:** The program can include training sessions for farmers, enabling them to interact with AI-powered tools confidently. Farmers can be encouraged to actively engage with the technology, ask questions, and provide feedback.
- **Resource Optimization:** AI algorithms can optimize irrigation schedules, recommend suitable crop varieties, and provide precise fertilization guidance. These recommendations can led to a significant reduction in water usage and chemical inputs while increasing crop yields/soil health and reducing environmental pollution.

5.4 Case Conclusion

Telangana's commitment to responsible adoption of AI in agriculture has not only improves the livelihoods of its farming communities but also paves the way for ethical, transparent, and sustainable practices. By harnessing AI to make data-driven decisions while ensuring fairness, transparency, and environmental sustainability, Telangana can set a precedent for other regions and nations. This case study demonstrates that AI can be a powerful tool for transformation in agriculture, delivering benefits that extend beyond productivity to encompass ethical and environmental considerations.

6 Conclusion

This paper presented a novel ETS Framework for responsible adoption of AI in agricuture for ensuring ethical, transparent and sustainable outcomes. This framework is a helpful tool to maximize the benefits of technology while safeguarding ethical, transparent, and sustainable outcomes for all stakeholders and the environment. By ensuring data privacy, mitigating bias, promoting transparency, and fostering collaboration, stakeholders can navigate the complexities of AI adoption and leverage AI technologies to promote sustainable and equitable agricultural practices.

This study is limited to the responsible adoption of AI in agriculture ensuring ethical, transparent and sustainable outcomes. This study can be extended to

apply this framework in multiple real-world cases and their comparison. It can also explore the challenges of adopting AI in agriculture and their respective solutions.

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Towards Hypothesis Generation for mHealth Applications: A Data Driven Approach

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Abstract. The rapid expansion of digital health research has led to the integration of Natural Language Processing (NLP) with traditional qualitative methodologies. While this convergence, remains promising in an exploratory phase, often demanding substantial resources due to a lack of standardized techniques. The mHealth domain, which encompasses a broad spectrum of healthcare applications, has undergone a transformation that now includes virtual consultations, remote monitoring, medication management, and health education. These advancements not only empower healthcare consumers to proactively improve their health outcomes but also facilitate healthcare providers in delivering immediate and responsive services. Overcoming challenges in this realm and harnessing these opportunities can potentially accelerate the integration of NLP methods into mHealth applications. The proposed data driven hypothesis generation analyze the existing literature of mHealth applications based in India and aims to identify patterns and gaps in knowledge that can form the basis for generating a novel hypotheses using computational techniques. The work mainly makes use of scientific literature corpus and embedded topic model to capture the importance of words in the document and find their semantic relations. Thus the generated hypothesis can guide further research, experimental design, or empirical investigations, driving data-driven discoveries in the field.

Keywords: mHealth applications · Computational Literature Review · hypothesis generation · qualitative methods · embedded topic model · embeddings

1 Introduction

A massive collection of scientific articles are knowledge base for research. Digital health research has recently attempted to integrate Natural Language Processing (NLP) with traditional qualitative methods. These methods remain exploratory

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and often resource-intensive, and there is little standardization of methods [1]. In the health sciences, combination of NLP and qualitative approaches have been used to cross-validate the different approaches [2]. Mobile technology finds applications across various domains including healthcare, communication, and governance services [3,4]. Mobile health(mHealth) refers to the use of smart devices(smartphones, tablets, and wearable devices) in the context of healthcare and medical services. The field of mHealth encompasses a wide range of healthcare applications and services. mHealth applications for healthcare have been progressively adapted to help consumers to improve their health outcomes, get access to proper healthcare services, help healthcare providers to deliver services in real time. Exploring these avenues can pave the way for the successful adoption of NLP approaches in mHealth applications, enabling more effective and personalized healthcare interventions and improving patient outcomes [5,6]. With the establishment of a strong digital platform Ayushman Bharat Digital Health Mission (ABDM) in India, it is possible to collect health information from doctors, patients, and health providers with a promise to have easy, flexible, and secure allowing different systems to work together. The features extracted from the user generated contents which is kind of unstructured data provide useful insights. A proof of concept analysis was conducted by combining NLP and quantitative analysis for an HIV mHealth forum [7]. Text mining, machine learning and systematic data analysis methodologies can be leveraged to automatize the generation of scientifically interpretable hypotheses. This primarily entails the extraction of information from extensive document repositories, subsequent pattern analysis and the identification of pertinent research inquiries [8]. Analyzing associations within scientific documents can result in the deduction of inventive relationships and the formulation of hypotheses, particularly in the context of translational research. The integration of computational literature review with the art of scientific hypothesis formulation elevates the accuracy and depth of knowledge synthesis.

2 Related Work

A conventional process of scientific research begins with background study and hypothesis generation. Once the data is collected, analysed then, the data analysis results are used to approve or revise the hypothesis [9]. The Computational Literature demonstrates how the abstract contents are analyzed automatically to provide a set of research topics within a literature corpus. This allows to analyse the literature [10]. The computational literature analysis of research has three dimensions, namely structure, impact and contents, wherein contents give the underlying latent topics which are majorly used in the particular domain [11]. Discovering latent variables/topic through computational literature review involves the application NLP and machine learning techniques text data, such as scientific articles or textual documents. Further more, one may come across embeddings which are learned sets of latent variables that describe the underlying qualities of a dataset that could not be observed directly [12].

Using embeddings for generating hypotheses leverages the rich semantic information captured by these representations to uncover hidden relationships and patterns within scientific literature. The automated hypothesis generation technique was proposed by using unsupervised knowledge discovery from the curated biomedical database [13]. In our study, the computational literature corpus constitutes the foundational input for the Embedded Topic Model (ETM), a data-driven methodology meticulously crafted to discern latent thematic constructs and uncover the concealed intricacies within the textual context.

2.1 Computational Literature Review

The ever-growing and complex scientific literature demands systematic, replicable and rigorous literature reviews, but the increasing volume makes them resource-intensive to conduct. The process of extracting and recognizing latent topics and patterns from complex scientific texts can be lengthy, time-consuming, and expensive due to the inherent limitations of human researchers. To address traditional literature review limitations, consider integrating computational methods with human researchers' insights for efficient analysis of large corpora.

Computational Literature Reviews (CLRs) are the new methodological guidance that helps in rigorous literature review [16]. CLRs use algorithms for text mining techniques to analyze the content of texts, going beyond effect sizes and meta-information. These advanced approaches transcend conventional methodologies by delving into the substantive content within textual corpora, thereby revealing intricate patterns and insights that may remain concealed when relying solely on traditional means, and bypassing the constraints of effect sizes and meta-information. CLRs are distinct from traditional manual literature reviews because they use algorithms to carry out review tasks without direct human involvement. This renders them entirely scalable and capable of real-time updates whenever new scientific articles emerge. Consequently, researchers can rigorously, efficiently, and promptly review even the largest and rapidly evolving scientific literature.

2.2 Scientific Hypothesis Generation

Hypothesis creates the path to the next state while clarifying the goals of hypothesis generation and hypothesis testing is important. It is also necessary to discuss how people currently generate hypotheses and how machine learning algorithms can be used to understand patterns and generate hypothesis [23]. The scientific hypothesis generation process from scientific articles' literature involves systematically reviewing and analyzing existing research papers to identify patterns, gaps and research questions that can lead to the formulation of testable hypotheses.

Studies have explored the directionality of thinking in scientific hypothesis generation processes and the evaluation procedures (confirmation or disconfirmation). Concepts are the exclusive units of information that are meaningful and provide relationships in terms of similarity and context [24]. Researchers have

observed limitations or biases wherein decontextualised factors are considered, such as the tendency to narrow existing hypotheses rather than generate them anew [20,21]. In fact, hypothesis generation is often highly dependent on contextual factors. Data-driven scientific hypothesis generation has been investigated by many researchers and validated by secondary data analysis [13–15,17,18]. Many experiments are carried out to automatically generate hypothesis using techniques of text mining, literature mining, machine learning, NLP, knowledge discovery and semantic web to find new patterns and relationships among different medical conditions like on diseases, genes, proteins [24–28]. The techniques of text mining, machine learning and systematic data analysis can be used to automate the process of generation of human interpretable scientific hypothesis [22]. Here it mainly involves extracting information from a large collection of documents, analyzing the patterns and identifying research questions accordingly.

3 Towards the Design of Robust Hypothesis Generation Using Data-Driven Method

For the design of hypothesis generation we use a data driven method where we use the corpus obtained from mHealth applications. The corpus obtained from the scientific literature is a repository of knowledge about mhealth applications, technologies. This corpus is then analysed using embedded topic models with a reason to find semantic relationships.

3.1 Literature Selection Criteria

The computational literature study for data-driven hypothesis generation using NLP starts with defining the research objective and then gathering relevant literature. The research endeavor is directed towards the systematic analysis of scientific articles with the aim of identifying the patterns through computational techniques in the domain of literature study. The research objective is to systematically analyze scientific articles, uncover patterns through computational literature study, while utilizing an NLP approach. Second, to identify the scientific hypothesis generation process through the scientific literature.

For this study, work related to mHealth applications in India was used. Further, we need to choose keywords that would filter relevant articles for our study. The keywords "(mHealth OR mhealth) AND applications" with the selection of filter country/territory as India were used. Thus we are able to build the corpus from the total of 429 documents that were extracted. This corpus also contains other details like authors list, identifiers which can be utilised for other analysis purposes. The next step is to analyse the literature from the abstract by a data driven method. The Fig. 1 depicts the comprehensive workflow of the study.

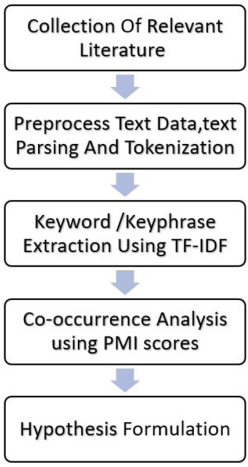


Fig. 1. Comprehensive workflow of the process.

3.2 Data-Driven Method for Analysing Scientific Literature

We have employed natural language processing (NLP) methodologies to systematically analyze a substantial corpus of scholarly literature text. This analytical framework aids in identifying latent patterns, relationships, and prevalent trends through computational methods. The key techniques involved in our work are text-preprocessing, part-of-speech tagging, topic modelling and co-occurrence analysis. We use these NLP techniques to make data driven decisions by utilising computational methods to analyze and understand literary works. These approaches empower researchers to make evidence-based claims and draw more robust conclusions from their analyses. NLP helps to uncover patterns and relationships from the keyphrases extracted from the literature corpus to draw more robust conclusions. The generated hypothesis can guide further research, experimental design, or empirical investigations, driving data-driven discoveries in the field. The richness of semantic relations of embeddings and the information measure of Pointwise Mutual Information are explored to extract deeper insights and uncover hidden patterns within text data.

Embedded Topic Modelling. Embeddings are valuable in this work as it captures the semantic meanings of the words, improve the interpretability, capture more meaningful and coherent keyphrases, resolve word sense ambiguities in topic modeling [29]. Text parsing and tokenization methods are involved in parsing the text of the abstract and tokenizing each term. This also involves in the removal of stopwords followed by lemmatization ending with a bag of words of relevant terms. Important keywords or keyphrases are extracted from the text corpus using techniques like TF-IDF. TF-IDF is preferred in text analysis for its ability to emphasize important terms, reduce noise, and enhance interpretability, making it compatible with a wide range of NLP tasks [34,35]. Furthermore,

wordtoVec model is used to create embedding to uncover latent topics/themes within the literature [31]. By combining TF-IDF with word embeddings the document representations that capture the importance of words in the document (TF-IDF) and their semantic relationships are obtained.

Pointwise Mutual Information. Pointwise Mutual Information (PMI) is a metric employed in natural language processing and information retrieval. It quantifies the degree of correlation between two occurrences of words or terms within a given text collection. PMI is used in hypothesis generation which involves identification of the possible association between the terms and relationships between different elements found in the literature data. In general the process involves creating a word co-occurrence matrix based on the corpus, where each row represents a word, each column represents another word, and the cell values represent the frequency of their co-occurrence [32]. The Pointwise Mutual Information (PMI) score is calculated using the formula

$$\mathrm{PMI}(A, B) = \log_2 \left(\frac{P(A, B)}{P(A) \cdot P(B)} \right) \tag{1}$$

where:

$\mathrm{PMI}(A, B)$ is the PMI score between terms A and B,
$P(A, B)$ is the probability of both terms A and B co-occurring together,
$P(A)$ is the probability of term A occurring,
$P(B)$ is the probability of term B occurring.

Using this matrix, Pointwise Mutual Information (PMI) scores are calculated to measure the strength of association between word pairs. We then filter the word pairs based on high PMI scores, indicating strong relationships between words. These high PMI score pairs are considered as potential hypothesis, suggesting meaningful connections. Specifically, we focus on the action part of words for generating hypothesis.

4 Results

We experimented our model using the R programming enriched with data science libraries. The code is implemented on a machine with Intel(R) Core(TM) i5-1235U CPU @ 1.30 GHz and 8,00 Gb of RAM. We used the concept of relationship between nouns and adjectives to convey descriptive and contextual relations within the text. The interaction between nouns and adjectives in the document can reveal patterns and themes that enhance our comprehension of the content. This synergy between nouns and adjectives enhances the accuracy and richness of insights that can be derived.

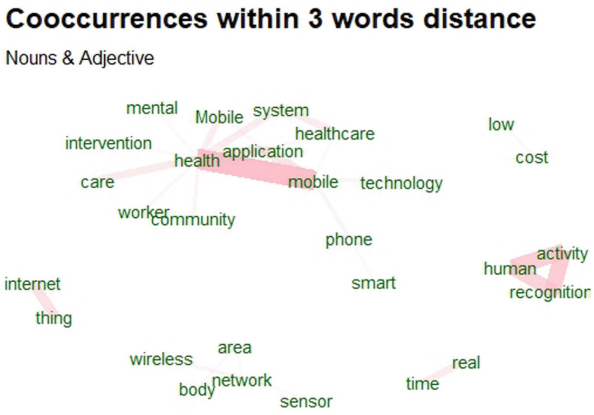


Fig. 2. Noun and adjective words following each other.

Nouns and adjectives following one another indicate in what applications mHealth apps are used. The Fig. 2 shows most of the mHealth application research is healthcare, where mental health is more emphasized with usage of internet of things, and wearable devices. It also infers that mHealth applications are applied with human activity recognition. To assess the importance of co-occurrences within a 3-word distance, we calculate statistical measure PMI to quantify the strength of association between terms.

Verbs often convey the main actions, events or processes associated with topics. Pointwise mutual information(PMI) on verbs (Fig. 3) reveals that most of the literature was pertaining to healthcare, applications that were stored, analysed, developed, collected or fabricated using some technology. Phrases like randomized control and supervised learning indicates frequent methods used in mHealth application literature.

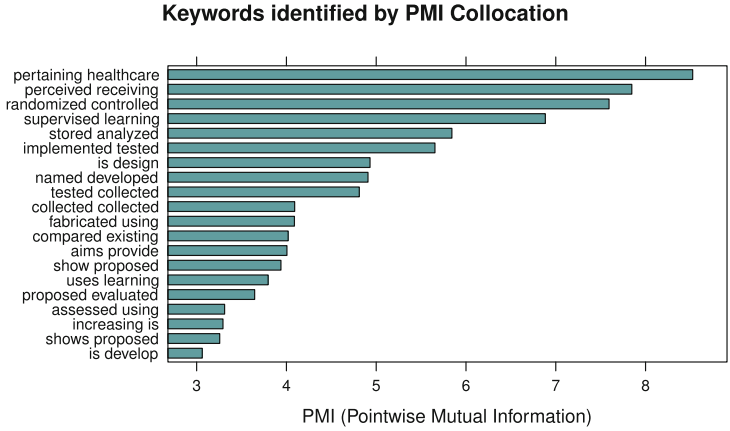


Fig. 3. Pointwise mutual information on verbs.

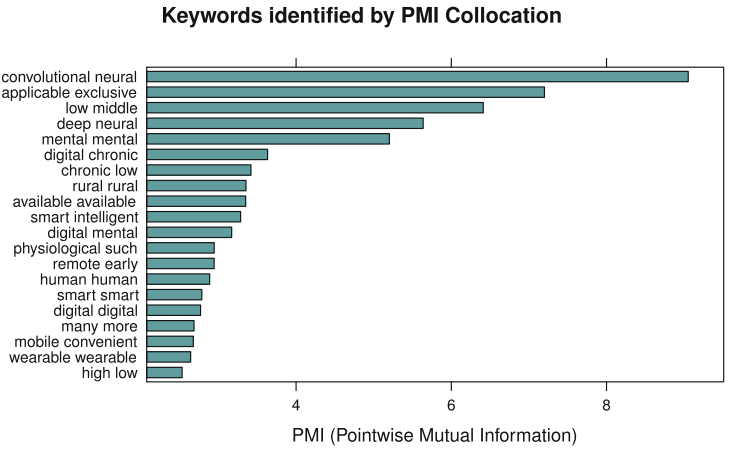


Fig. 4. Pointwise mutual information on adjectives.

PMI on adjectives (Fig. 4) reveals that most of the literature emphasises applications for early detection, mental health, digital chronic, psychological, remote early, and exclusive applications. These keywords also indicate the technology and major algorithm used for the research. Phrases like convolution neural and deep neural indicate that these are the major techniques used.

The Fig. 5 gives a preview of the topics that are clustered. The major part of topics are overlapped, indicating the domain discusses related concepts using similar words or phrases. The Fig. 6 shows the association of words derived from the domain knowledge according to the research objective with the keywords formed from the process. Since functionally related concepts are grouped, we may assume that concepts that are close but only indirectly related in the group may also be functionally related in the real world. This indicates the common associations of keywords formed and helps to generate a hypothesis.

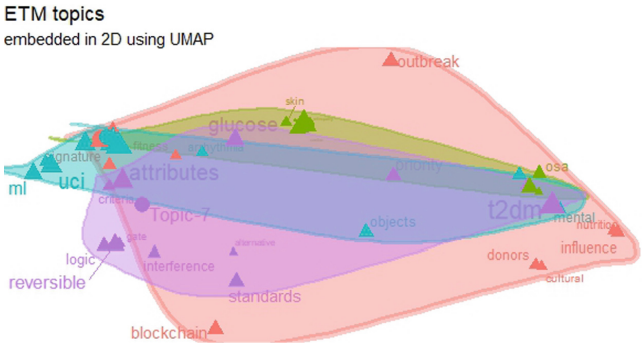
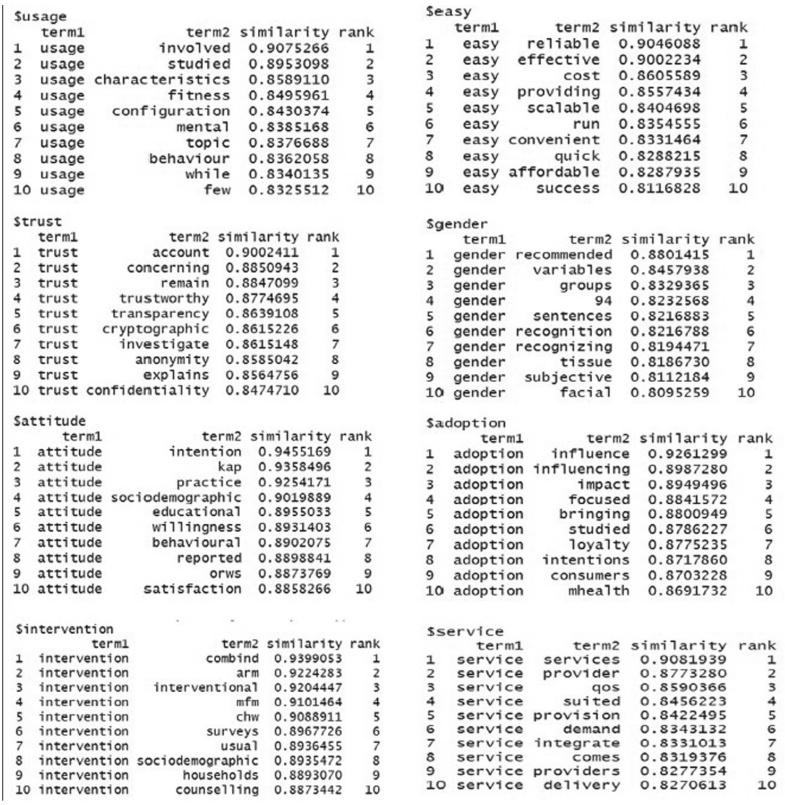


Fig. 5. ETM topics embedded in 2D using UMAP



$usage

	term1	term2	similarity	rank
1	usage	involved	0.9075266	1
2	usage	studied	0.8953098	2
3	usage	characteristics	0.8589110	3
4	usage	fitness	0.8495961	4
5	usage	configuration	0.8430374	5
6	usage	mental	0.8385168	6
7	usage	topic	0.8376688	7
8	usage	behaviour	0.8362058	8
9	usage	while	0.8340135	9
10	usage	few	0.8325512	10

$easy

	term1	term2	similarity	rank
1	easy	reliable	0.9046088	1
2	easy	effective	0.9002234	2
3	easy	cost	0.8605589	3
4	easy	providing	0.8557434	4
5	easy	scalable	0.8404698	5
6	easy	run	0.8354555	6
7	easy	convenient	0.8331464	7
8	easy	quick	0.8288215	8
9	easy	affordable	0.8287935	9
10	easy	success	0.8116828	10

$trust

	term1	term2	similarity	rank
1	trust	account	0.9002411	1
2	trust	concerning	0.8850943	2
3	trust	remain	0.8847099	3
4	trust	trustworthy	0.8774695	4
5	trust	transparency	0.8639108	5
6	trust	cryptographic	0.8615226	6
7	trust	investigate	0.8615148	7
8	trust	anonymity	0.8585042	8
9	trust	explains	0.8564756	9
10	trust	confidentiality	0.8474710	10

$gender

	term1	term2	similarity	rank
1	gender	recommended	0.8801415	1
2	gender	variables	0.8457938	2
3	gender	groups	0.8329365	3
4	gender	94	0.8232568	4
5	gender	sentences	0.8216883	5
6	gender	recognition	0.8216788	6
7	gender	recognizing	0.8194471	7
8	gender	tissue	0.8186730	8
9	gender	subjective	0.8112184	9
10	gender	facial	0.8095259	10

$attitude

	term1	term2	similarity	rank
1	attitude	intention	0.9455169	1
2	attitude	kap	0.9358496	2
3	attitude	practice	0.9254171	3
4	attitude	sociodemographic	0.9019889	4
5	attitude	educational	0.8955033	5
6	attitude	willingness	0.8931403	6
7	attitude	behavioural	0.8902075	7
8	attitude	reported	0.8898841	8
9	attitude	orws	0.8873769	9
10	attitude	satisfaction	0.8858266	10

$adoption

	term1	term2	similarity	rank
1	adoption	influence	0.9261299	1
2	adoption	influencing	0.8987280	2
3	adoption	impact	0.8949496	3
4	adoption	focused	0.8841572	4
5	adoption	bringing	0.8800949	5
6	adoption	studied	0.8786227	6
7	adoption	loyalty	0.8775235	7
8	adoption	intentions	0.8717860	8
9	adoption	consumers	0.8703228	9
10	adoption	mhealth	0.8691732	10

$intervention

	term1	term2	similarity	rank
1	intervention	combind	0.9399053	1
2	intervention	arm	0.9224283	2
3	intervention	interventional	0.9204447	3
4	intervention	mfm	0.9101464	4
5	intervention	chw	0.9088911	5
6	intervention	surveys	0.8967726	6
7	intervention	usual	0.8936455	7
8	intervention	sociodemographic	0.8935472	8
9	intervention	households	0.8893070	9
10	intervention	counselling	0.8873442	10

$service

	term1	term2	similarity	rank
1	service	services	0.9081939	1
2	service	provider	0.8773280	2
3	service	qos	0.8590366	3
4	service	suited	0.8456223	4
5	service	provision	0.8422495	5
6	service	demand	0.8343132	6
7	service	integrate	0.8331013	7
8	service	comes	0.8319376	8
9	service	providers	0.8277354	9
10	service	delivery	0.8270613	10

Fig. 6. Association of common keywords used in the domain knowledge with words present in the literature.

The hypothesis formed from the word pairs with high PMI values reveal interesting and previously unknown associations within the data. Conversely, pairs with low PMI values can also be important, as they represent rarely occurring word combinations. The generated hypothesis can be further evaluated using various analytical methods to gain deeper insights into the underlying relationships and patterns in the data. Lastly, validating against the research objective and existing knowledge and using ETM to predict co-related terms against the common words that are used in domain knowledge, the hypothesis is derived. Validating the generated hypothesis can be done using expert opinions based on their domain knowledge expertise, comparative analysis, or using case studies.

5 Conclusion and Future Work

Conducting a comprehensive literature review is a valuable method for hypothesis generation. By reviewing existing research and scholarly works, researchers can identify gaps in knowledge, controversies, and emerging trends that may

inspire new hypothesis. The combination of embeddings and PMI shows how text analysis is improving. The concurrent utilization of multiple methodologies enhances our capacity to extract valuable insights and knowledge from the existing body of scientific literature. Thus data driven process promises to give this valuable knowledge from the corpus of mHealth domain. Knowledge base construction involves the systematic extraction of information from various sources and the organization of that information into a structured knowledge base. Once the knowledge base is constructed, it can be used to generate paths, which are sequences of relationships or connections between entities. These paths can be analyzed to draw conclusions and formulate hypothesis.

NLP models developed on specific datasets may lack generalizability across different healthcare contexts, populations, or languages. Ensuring external validity and adapting NLP approaches to diverse settings is essential for broadening their applicability. Expert opinions, based on their domain knowledge and experience, can inspire new research questions and hypothesis. Through comparative analysis, researchers may generate hypothesis about the factors influencing the observed differences followed by case studies. In-depth analysis of specific instances, often through case study research, allows researchers to formulate hypotheses rooted in detailed observations and unique characteristics. These hypotheses contribute to a deeper understanding of the phenomenon under investigation and can guide subsequent research and decision-making processes.

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An Analysis of the Barriers Preventing the Implementation of MLOps

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Abstract. The rapid improvements in machine learning (ML) and the increasing importance of ML models in numerous industries have resulted in the emergence of MLOps (Machine Learning Operations), a discipline focusing on efficiently managing and operationalising ML workflows. This exploratory study investigates the difficulties encountered when implementing MLOps within organisations and compares MLOps to DevOps. The study begins by conducting an SLR to identify the challenges mentioned in the literature. We then explain the results of conducting semi-structured interviews with 12 ML practitioners working across many industries, perform qualitative content analysis using grounded theory, and discuss findings. Findings are organised along four distinct dimensions: Organisational, Technical, Operational and Business challenges, which are explained in eleven different themes. Our findings show that MLOps has some challenges that overlap with DevOps as well as some specific only to MLOps, like the complexity of data and model. In our discussion, we summarize these challenges and suggest future recommendations.

Keywords: Machine learning Operations (MLOps) · Grounded theory · Data Science

1 Introduction

Machine learning (ML) has advanced dramatically in the last two decades, becoming a widely utilised practical technique in commercial use, especially within AI. It is the method of choice for creating useful software for various applications, including robot control, speech recognition, computer vision, and natural language processing. And it is commonly utilised in computer science and other fields that deal with data-intensive problems (Jordan and Mitchell, 2015). As AI has grown in popularity and usage, an increasing number of businesses have begun to rely on it as a major component of their business models and hence on Machine Learning. The 2019 McKinsey Global Survey on the topic found that the usage of AI in standard business activities has increased by over 25% year over year (Arif Cam et al. 2019).

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The widespread adoption of ML-based approaches has brought a major challenge in integrating them into production systems while ensuring reliability and efficiency in continuously evolving ML projects (Rzig et al. 2022). However, only 13% of machine learning projects in the industry reach production, according to a VentureBeat report (VB Staff, 2019). The practices have shown that although appearing to be the last 10% of the project, deploying prototypes to production can take up 90% of the time (Flaounas, 2017). To address these obstacles, the concept of MLOps (Machine Learning Operations) has arisen to establish a comprehensive set of practices designed to ensure the reliable and efficient deployment and maintenance of machine learning (ML) models in production environments (Alla and Adari, 2020).

MLOps is a modification of the DevOps discipline, which has been around for over a decade and was developed to address similar issues with continuous deployment, but for standard software. In contrast to DevOps, MLOps aims to address issues unique to machine learning, such as model and data versioning, continuous training, model monitoring, and model testing. Organisations are incorporating continuous practices in ML system development through the adoption of DevOps concepts for end-to-end automation (John et al. Sep 2021) as containerised microservices and cloud-based DevOps have proven to be successful in production deployments (Hui Kang et al. Apr 2016). According to Gartner's (2022) hype cycle for data science (DS) and ML, MLOps is currently in the "Peak of Inflated Expectations" phase (Choudhary and Krensky, 2022).

Despite MLOps' rising popularity, scholarly literature on the adoption of automation and its effects on modifications in ML-enabled systems is limited (Calefato et al. 2022). Our knowledge of MLOps is now restricted to a dispersed landscape of white papers, anecdotes, and opinion pieces (Shankar et al. 2022). John et al. (2021) also mention that a large portion of the literature on software engineering (SE) best practices for ML applications is non-peer-reviewed or grey literature (John et al. 2021), which includes blog postings, presentation slides, and white papers (Serban et al. 2020). Most authors concur that MLOps is difficult. 85% of ML initiatives fail to provide value, while 90% of ML models never reach production (Shankar et al. 2022). In their investigation of MLOps projects in GitHub, Calefato et al. (2022) found very few production-grade ML projects. They also highlighted the lack of open-source ML-enabled systems utilising MLOps tools (Calefato et al. 2022). There are papers talking about the challenges of implementing MLOps technically (Symeonidis et al. Jan 26, 2022) and suggestions on how to overcome these (Cardoso Silva et al. 2020) but there are very few articles on real case studies from organisations.

In this paper, we concentrate on examining the difficulties organisations encounter while implementing MLOps as there is limited research that contextualises the literature on MLOps, highlights the difficulties associated with MLOps, and provides a comprehensive synthesis of recent material. Our research question is therefore:

What are the challenges organisations face while implementing MLOps?

Our findings from the SLR indicate that there is a general shortage of empirical data on MLOps, as well as several implementation issues. While the findings from our interviews reveal four distinct dimensions of challenges: Organisational, Technical, Operational and Business challenges, which are then explained in eleven different themes.

The remainder of this paper is structured as follows. Section 2 provides results from the Systematic Literature Review. Section 3 describes our methodology, while Sect. 4 presents and analyses the results of the Interviews. Finally, in Sect. 5 we discuss and conclude the paper with implications for research and practice.

2 Literature Background

We first conducted a systematic literature review to understand the challenges faced by organizations while implementing MLOps. The protocol adopted to conduct the SLR included the following activities: (1) setting a research question; (2) selecting relevant studies; (3) extracting data; and (4) synthesising the data collected (Kitchenham, 2004). For this SLR, a manual search through electronic research databases was used as the search approach. Due to restrictions of time, only two major databases will be considered. The databases chosen are SCOPUS and ScienceDirect, as these databases are extensively used to access scholarly articles in machine learning and artificial intelligence.

Table 1. Concept matrix of challenges faced in MLOps

Articles	MLOps Challenges – Concept matrix									
	Model Issues (Scalability, accuracy, Versioning, Monitoring)	Data Issue (Availability, quality, privacy)	Integration and Infrastructure	Regulatory Compliance	Standardization	Tools Support for MLOps	Testing	Lack of Talent	Collaboration & communication	Lack of Knowledge
Paleyes et al. (2022)	✔	✔	✔	✔	✖	✖	✖	✖	✖	✖
Granlund et al. (2021)	✔	✔	✔	✖	✖	✖	✖	✖	✔	✔
Lima et al. (2022)	✔	✔	✔	✖	✔	✖	✖	✖	✖	✖
Baier et al. (2019)	✔	✔	✔	✔	✔	✔	✖	✖	✔	✔
Tamburri (2020)	✖	✔	✖	✔	✖	✖	✖	✔	✖	✔
Painoli and Datrike (2021)	✔	✔	✔	✖	✖	✖	✖	✖	✖	✖
Schröder and Schulz (2022)	✖	✔	✔	✖	✖	✖	✔	✖	✖	✖
Testi et al. (2022)	✔	✔	✖	✖	✔	✖	✖	✖	✖	✔
Zhang et al. (2020)	✔	✔	✖	✖	✖	✖	✖	✔	✖	✔
Total	8	9	6	3	3	1	1	2	2	5

Since MLOps is a relatively young field and the name MLOps gained popularity with the idea of "Hidden Technical Debt in Machine Learning Systems" in 2015 (Sculley et al. 2015), the search is restricted to only retrieving results for the years 2015–2023. The inclusion and exclusion criteria used for the SLR are described in Table 3, and Table 4 (in Appendix A).

The search terms "MLOps" OR "machine learning in production" OR "machine learning operations" were used in the first box to generate the initial results and limited from 2018 to 2023. The search yielded 229 hits in SCOPUS and 323 hits in Science Direct. Only research articles and conference papers were selected and considered articles that had open access. This left us with 175 papers. The first author then proceeded with a manual screening of the document abstract to look for the selection criteria. And after reading the remaining documents to look for challenges in MLOps, ten articles were selected for data extraction and synthesis. The process described in this section can be found in Fig. 2 (in Appendix B).

We identified a total of nine papers that touch upon MLOps' challenges. It is important to note that not all these papers solely focused on MLOps, but rather addressed related aspects within the broader context of machine learning operations. To ensure the relevance of the selected content, we have chosen to include only those sections that directly pertain to the challenges associated with MLOps in this study. Table 1 showcases the concept matrix (Webster and Watson, 2002) for the challenges of MLOps.

Baier et al. (2019) analysed the MLOps in practice and discovered some of the unique challenges that organisations face when deploying ML models in production (Baier et al. 2019). These challenges included the quality and quantity of data. They also identify data validity as well as tackling concept drift as a unique challenge of MLOps. Besides the technical challenges of MLOps in organisations, Baier et al. (2019) also looked at some of the non-technical challenges of MLOps. These challenges included a lack of collaboration and communication among the technical and non-technical teams, Integrating and Streamlining the ML model into existing business operations, and organisational and national standards of ethical and legal compliance.

Tamburri (2020) covered a range of internal and external challenges that organisations face in MLOps. They list the organisational challenges when deploying MLOps, such as integrating MLOps with existing IT infrastructure which can cause sustainability and scalability issues, further trickling down the effect on workflows and causing disruptions. The significant concerns are, ensuring MLOps alignment with the organisation's goals and values raises and the safety and security of the MLOps pipeline so that the deployed ML model is compliant with the relevant regulations and standards of the areal jurisdiction in its entirety. Another big challenge for organisations is to find relevant, experienced, and motivated talent with the skillset needed for MLOps (Tamburri, 2020).

While there are challenges to implementing MLOps in an organisation, these challenges take a different shape when considering multiple organisations (Granlund et al. 2021). Granlund et al. (2021) note that in an organisational setting, the ML models are continuously updated due to new data sets being generated and integrated and new features being discovered and added to the feature set fed to the ML model. Therefore, it becomes a pressing challenge for MLOps to produce the capability of deploying an updated ML Model which allows for instantaneous and efficient deployment. Other prominent challenges in MLOPs discussed in this paper are the Integration Challenge and the Scaling Challenge. The integration challenge occurs when multiple organisations may have incompatible APIs due to different contractual obligations, data formats, and ML features.

Lima et al. (2022) explore the various MLOps practices and challenges in organisational frameworks. These challenges include ML model versioning that deals with deploying the correct model from a range of different versions of the ML models developed during the ML pipeline. The authors also describe the lack of standardisation as a source of massive resistance in MLOps, even within the internal teams of organisations. Since ML models, datasets, and feature sets can be produced using numerous tools on a wide range of platforms (Lima et al. 2022).

Testi et al. (2022) wrote about challenges that included explainability and transparency of the ML models and decisions. A proper understanding of the ML model via transparency and explainability is fundamental in the context of MLOps for organisations since the factors contributing to various decisions of the ML model must be known accurately. Another significant problem encountered by organisations implementing MLOps is limited and isolated research as well as a lack of standardisation and best practices. Additionally, Testi et al. (2022) found that organisations were having difficulty addressing the constantly changing data, which sometimes requires retraining or even a complete rebuild of the model in the ML pipeline.

Painoli and Datrike (2021) focus on generic AI challenges in organisations. The authors call attention to companies having difficulties deciding on an acceptable algorithm, methods for cleaning their data, and determining which attributes to include in their model. The authors also note that infrastructure, data privacy, and security issues are obstacles that must be overcome for successful deployment. Organisations also have difficulties comprehending and disseminating the model's outcomes due to a shortage of competent staff. The authors conclude that one of the biggest challenges in deploying AI/ML is ensuring the model is accurate, fair, and transparent when making decisions (Painoli and Datrika, 2021).

Paleyes et al. (2022) conduct a survey of case studies to highlight difficulties in adopting machine learning models. They observe that businesses commonly face problems with data management, choice of models, and feature engineering. The authors also stress the necessity for thorough testing and validation methods and the significance of models' interpretability and explainability. They also mention that there might be difficulties in implementing machine learning models due to a lack of infrastructure and experienced staff. The authors note the growing importance of data protection and ethical concerns such as fairness and transparency when implementing machine learning models (Paleyes et al. 2022).

Schröder and Schulz (2022) explain organisational difficulties in Monitoring ML models while focusing on operations. Problems with data quality, mislabelling, and data drift are highlighted. The authors also stress the necessity to monitor the performance of the model and solve concerns of bias, fairness, and interpretability. They also point out that it might be difficult for businesses to adopt and integrate monitoring systems into pre-existing infrastructures (Schröder and Schulz, 2022).

Zhang et al. (2020), on the other hand, suggest that knowledge-intensive work presents unique difficulties in developing machine learning AI systems. Resistance to change and inefficient adoption might result from not knowing how to integrate AI with current organisational systems and procedures. Another obstacle they mention is striking

a balance between accuracy, accessibility, and complexity when deciding which models and algorithms to use among the many that are accessible. Since AI systems need extensive volumes of data to learn, data quality concerns may have a detrimental effect on performance, thus presenting another difficulty. Moreover, multidisciplinary teams with varied skill sets are difficult to find and manage, and they are essential for building AI systems (Zhang et al. 2020).

3 Methodology

Inductive reasoning based on qualitative data is especially appropriate when there is little prior research or when the empirical setting is novel or understudied (Bansal et al. 2018). We therefore first conduct a systematic literature review (SLR) to get a broad overview of relevant research and, in parallel, do semi-structured interviews with ML experts from various industries. The findings of the SLR are then compared with findings from expert interviews (in the discussion section) to draw relevant conclusions.

Data for the research was collected by conducting individual interviews with participants who have knowledge about MLOps and can provide a perspective on it. This is a commonly used data collection strategy (Beitin, 2012). We used a purposeful sampling technique to find participants with experience working with machine learning and/or its operations with job titles such as Data scientist, ML Manager, MLOps engineer, or comparable titles. Table 5 (Appendix C) shows the overview of interview participants. We used an in-depth, semi-structured interview method which allowed us to change the ordering of questions or ask about the relevant finding of one interview to another (Qu and Dumay, 2011).

We used ATLAS.ti, a computer-aided qualitative data analysis software (CAQDAS), to organise, analyse, and visualise semi-structured data. The data were analysed inductively using a grounded theory approach while reflecting on the research question (Charmaz, 2006). After the first two interviews' transcription, we started coding the quotations, which is also commonly known as open coding. Coding, in general, involves giving short labels to groups of data (Boeije, 2010).

Codes were added and compared to the prior data after each interview's transcription was finished, illustrating underlying coding as a process of ongoing comparison. The continual comparison of data items ensured that the data coding and the analytic process were consistent (Saunders et al. 2012). We initially had 102 open codes, but after multiple iterations and keeping the focus on the research question, we reached saturation and ended up with 51 first-order codes. As saturation had been reached, the 11th and 12th interview transcriptions did not yield any new codes, but we chose to utilise the quotes from them to broaden the study's applicability.

4 Results

After the analysis of the findings, a diagrammatic representation of themes and the core categories is represented in the conceptual model (Fig. 1). This model shows the relevant themes (blue) under the aggregate dimensions (yellow). The first-order concepts are not explicitly shown here but can be found in the coding scheme (Fig. 3 in Appendix D).

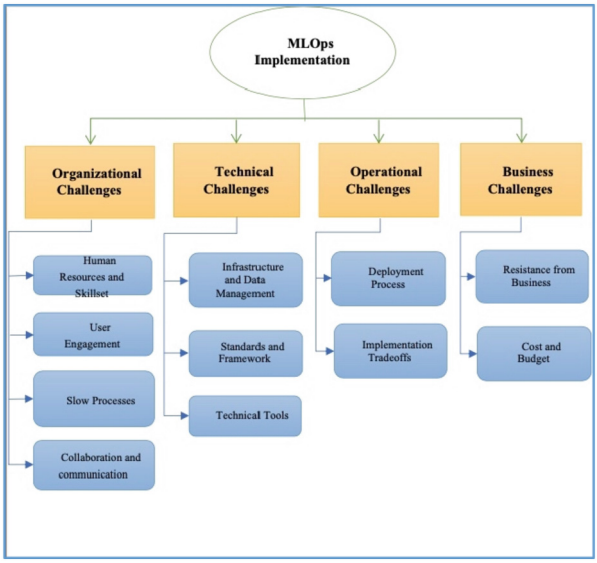

Fig. 1. The conceptual model of challenges in MLOps implementation

Table 2. Code Density

Category	Themes	Codes	Total density
Organizational Challenges	Human Resources and Skillset	7	23
	User Engagement and Resistance	4	
	Slow Processes	8	
	Collaboration & Communication	4	
Technical Challenges	Infrastructure and Data Management	7	14
	Standards and Framework	4	
	Technical tools	3	
Operational Challenges	Difficulties in Pipeline	4	7
	Implementation Trade-offs	3	
Business Challenges	Business Value	2	7
	Cost and Budget Constraints	5	

4.1 Organizational Challenges

The data was grounded and had high-density codes for the organisational challenges, as shown in Table 2, which consists of four themes explained in detail below.

Human Resources and Skillset: The machine learning world is new to corporates, which brings with it the resources challenges. One of the issues raised is that the resources hired for machine learning engineering tasks sometimes lack practical experience. What

they studied in college or school may not be applicable in real-world settings. This indicates a misalignment between academic education and industry requirements. As a result, these resources necessitate a substantial amount of time for onboarding and developing the essential skills and experience to take data ownership.

"*We have been facing the problem for the last 5–6 years regarding the resources not being ready, and sometimes what they have learned in their college or in school is not practical enough. So, the onboarding time for machine learning engineers is 6 to 7 months. Only after six to seven months can you trust them that they can take data ownership,"- Participant 1.*

The other challenge is not having all the relevant skills needed to build MLOps pipelines in one team or sometimes even within the organisation leading to knowledge gaps.

User Engagement and Resistance: As there is a lack of talent, it is important to train existing team members in these new tools, and sometimes it leads to resistance. "*Because along with our pipeline came all the new learning to do, which was challenging for some team members to adapt to these new tools." – Participant 11.* When the MLOps pipelines are built, if it's not used by the teams developing ML applications, then there is no perceived value for these pipelines. As Participant 7 said, "*I would say the biggest challenge was keeping the teams that we worked with and for involved and interested. We spend a lot of time involving different teams and making them feel engaged in the process because our biggest challenge was not making the model or making the pipeline, but getting people to just think about using it and making people see the benefits."*

Organisational culture has an impact on reducing the resistance to adoption; as Participant 1 describes, *"Culture is really here good because it is a data-based company, and that is why the situation is better,*" showcasing that they did not face any resistance from teams for using the latest MLOps tools.

Slow Processes: A common topic spoken by multiple participants is that the way organisations and teams are set up plays an important role in enabling MLOps. Usually, multiple teams are involved in making MLOps a success, but they do not have the same priorities making the dependencies last longer than anticipated. Participant 1 shared, *"Very often, it's not one team that manages this whole thing, and that means that if you, for example, have a data engineer that works with you from a different team, they're also working on other projects. And they need to manage all of those, and that means that they always don't always have time to help you out with whatever you need at that time, causing delays.*"

Collaboration & Communication: When there is limited knowledge about machine learning models and data within the organisation, it can lead to a lot of collaboration issues show the findings. MLOps need diverse teams, including data scientists, developers, and ML engineers, who all have different priorities and objectives, making effective coordination difficult. When all the required skillsets are not part of a single team, it could lead to miscommunications and collaboration challenges; Participant 7 shared, *"Very often it's not one team that manages everything that means that they always don't always have time to help you out with whatever you need making collaboration difficult."*

As multiple teams are involved, communication does not always go smoothly. Also, communicating model changes to customers who do not have a background in ML is very difficult, participants add.

"You get a lot of miscommunications between those teams and a lack of accountability or responsibility. Because it's a lot easier to say. Yeah, there's a problem. That's not my problem. That's their problem. And you just start going in circles." -Participant 7.

4.2 Technical Challenges

Implementing MLOps in an organisation involves several technical challenges. After the organisational challenges, more codes in the data were generated about technical challenges. These challenges arise due to multiple reasons like the complexity of machine learning models, lack of data, or the integration of various tools and technologies. This is explained under three themes below.

Infrastructure and Data Management: To build pipelines for ML models is a complex task, and the underlying infrastructure plays a big role in it. It takes a reliable infrastructure to implement machine learning models in production. To run models at scale, organisations need to make sure that the deployment environment can accommodate the additional computing and storage needs. It seems to be challenging to scale up resources, maximise hardware efficiency and manage distributed systems. If the infrastructure which is set up does not match the technical stack for ML applications, it also leads to integration issues.

It seems effective data management and governance for data are critical in MLOps. Organisations need to ensure the availability, quality, and security of data used for training and inference. As Participant 6 says, *"I think the big challenge we have is the enormous variation in data. As I mentioned, we have half a million models, so it's very hard. If the data sets are very different, then the data quality is very different. Customers are not interested in low-quality results."* MLops is as good as the data that is provided through the pipeline; Participant 3 uses the analogy '*garbage in garbage out*' and elaborates, "*The entire MLOps output really depends on how good your data quality is and rather not on MLOps."*

Standards and Framework: There seems to be a "*gap in the best practices provided by industry leaders and the development of the technology",* says Participant 10. Solution providers and industry leaders should make the standards and frameworks, but it seems it is currently lacking in many places. The lack of detailed and accessible documentation makes it difficult for teams to comprehend and efficiently use open-source tools, resulting in discrepancies and implementation issues.

Writing unit tests to check code quality is a common practice in traditional software development. However, due to the non-deterministic nature of ML models, testing becomes more challenging in the context of machine learning. Testing machine learning systems necessitates specific approaches and procedures that extend beyond basic software testing, adding complexity to the standardisation of testing practices.

"*For regular software, I'm used to writing unit tests. For machine learning, these tests are a bit more complex because it's not deterministic." – Participant 3.*

Technical Tools: what is mostly mentioned by the interviewees is that having the right technical tools is one of the important requirements while implementing MLOps.

Two interviewees mentioned there are "*a variety of tools available*", but one must choose the right tool based on the business needs, and it is a "*tough job*". And if one finds a good MLOps platform, it is also very expensive.

Challenges regarding technical tools highlight the difficulties that organisations encounter. Instability, lack of integration, restricted capability, and the requirement for customisation can all impede the efficiency and effectiveness of MLOps procedures. It emphasises the significance of thoroughly evaluating and testing tools, staying up to date on the latest advances, and considering the organisation's MLOps-specific requirements and constraints.

4.3 Operational Challenges

Two themes were discovered in the interview data regarding operational challenges, which are closely connected to technical challenges but have more emphasis on everyday operations.

Deployment Process: There are technical challenges concerning data, tools, and infrastructure, as mentioned before, in the deployment pipeline. But there are also some operational challenges that interviewees mentioned. The complexity of continuous integration in MLOps versus DevOps is one operational challenge mentioned. According to interviewees, MLOps necessitates a more comprehensive and complex approach to continuous integration.

Another problem is generalising and automating the deployment procedure. Developing a deployment process that works well across multiple data sets with varying statistical features is a difficult undertaking. Automating the training, algorithm selection, tweaking, and other processes to get satisfactory results over a wide range of data sets necessitates careful design and study.

Dependencies on other teams can be a challenge in MLOps. One interviewee mentions that their team relies on deployment pipelines and API hosting services maintained by other teams. If these external dependencies encounter issues, it can impact the MLOps team's operations.

Implementation Trade-Offs: Another aspect mentioned by interviewees in implementing MLOps is tradeoffs. ML developers frequently encounter challenges when deciding between competing criteria, such as cost versus prediction speed.

Organisations must weigh the reliability and integration benefits of off-the-shelf items against the expenses associated with them.

In MLOps, there is a tendency to over-engineer solutions, which can result in excessive time and resource waste. It is critical to strive for constant improvement and optimisation, but there should also be practical boundaries to avoid over-engineering, which reduces efficiency.

4.4 Business Challenges

Resistance from Business: Obtaining top-level buy-in and support is always vital, but this is especially true for MLOps projects shared by interviewees. Processes are becoming more complex, and it is hard to explain the return on investment to businesses.

On the other spectrum, some businesses see AI as an answer to all problems. This viewpoint is frequently expressed by non-technical stakeholders who follow the latest buzzwords without examining the context. This viewpoint can create challenges in managing expectations and educating the business on the limitations and realistic outcomes of MLOps projects. Participant 3 explains that when it is a "simple descriptive analytics project", the organisation should not look for AI/ML solutions but rather "building a dashboard will suffice."

Customers frequently have high expectations of the system, expecting 100% accuracy and comprehensive problem-solving. It might be difficult to manage these expectations and educate customers about the limitations and risks of machine learning models.

Cost and Budget Constraints: When businesses do not understand what value MLOps brings, they do not allocate enough budget for it, it seems. And sometimes budget is allocated to "market the product more than investing in the infrastructure", shares an interviewee. It gets difficult to "change the tools or underlying legacy systems" as the business has a sunk cost fallacy mindset.

Management and Business may support the idea of MLOps until a budget is asked for it, explains Participant 7, "*When we started, it was open and free for us to experiment. I didn't feel any restrictions. Later, when we posed the question: could we have a managed Kubeflow environment? And then we did feel the restrictions in terms of budget.*"

4.5 MLOps vs DevOps

MLOps is viewed as an extension of DevOps, with the key difference being the introduction of model deployment-specific components. Understanding and adapting to these new components while exploiting existing DevOps processes seems to be the challenge. MLOps, like DevOps, faces difficulties in developing a robust environment and promoting collaboration across teams (Erich et al. 2017). It seems to be difficult to ensure seamless integration, effective communication, and coordinated activities among various parties. However, unlike DevOps, MLOps deals with machine learning models, which frequently introduce unknown and complex techniques. Addressing and accounting for these risks becomes a problem, requiring significant thought and planning.

"MLOps is DevOps that is applied to machine learning. But the challenge is there are a lot of unknown processes that make it a bit more difficult."-Participant 9.

5 Discussion and Conclusion

Over the past few years, machine learning (ML) applications have sparked several new technological advancements in both academia and business. However, there are still a lot of unsolved questions regarding the use of ML in practical applications (Shollo et al. 2022) and many projects do not make it to production (Shankar et al. 2022). MLOps, an extension to DevOps seems to be the solution for deploying ML-based software to production yet it has not been adopted by many organisations. In this paper, we answer the research question *"What are the challenges organisations face while implementing MLOps*" by conducting a structured literature review and a semi-structured interview with 12 ML experts working in different organisations.

Our findings reveal that the organisational adoption of MLOps is not without its difficulties. It is challenging to find suitable people with the necessary skill sets in data engineering and machine learning engineering, which are essential for creating MLOps pipelines. High market demand makes it difficult to retain talent. The efficient use of MLOps pipelines may be hampered by some team members' resistance to utilising new tools and technology. Organisations must make sure that teams creating ML applications are aware of and utilising the value of MLOps. MLOps are greatly facilitated by organisational design and decision-making processes. Long approval processes might limit engineers' autonomy and delay implementation. Collaboration and communication issues develop because of insufficient skills and different goals within MLOps teams. This is also an existing challenge of DevOps. Some of the technical challenges discovered are managing large amounts of data within pipelines, scaling up the ML infrastructure as data and models grow, limited availability of clean and production data, integration issues with existing IT systems, and difficulties managing and scaling the underlying infrastructure. Operational challenges include the difficulty of continuous integration, dependency on other teams (also a recognised challenge for DevOps), and the need to make trade-offs between priorities and optimisation efforts. And lastly, business-related challenges found in this research are explaining the business value of MLOps to management and getting budget allocations.

This exploratory study was designed to add knowledge about factors that hinder the implementation of MLOps. Relating the themes to common challenges recognised in the other technological implementations adds depth to the literature review. Literature focuses more on technical challenges such as data availability, data drift, model versioning, scalability, and model monitoring (Baier et al. 2019; Lima et al. 2022; Testi et al. 2022). However, this paper provides insights into the issues related to the integration of tools into existing infrastructure, managing data privacy, and not having enough standardization of MLOps tools. It also provides insights into the challenges which are non-technical as well. Lack of knowledge, human resources, budget constraints, and unclear business value are some of those. By comparing MLOps challenges to DevOps, this thesis showcases the challenges which are found in both practices. Practitioners can look at this to get an overview of challenges and try to reduce these at an organisational level. Tool vendors can look at the technical challenges mentioned to provide possible solutions in their latest tools. The findings contribute to models or frameworks concerning technology adoption and implementation challenges. In general, most interviewees stated that they believed our research about this phenomenon is very relevant, and hence a copy of this would guide them further. Future research could also explore the prerequisites and benefits of MLOps (as shown in Appendix E).

Appendix A-D

Are available here: https://ashwinikn30.github.io/

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Assessing the Factors Influencing the Adoption of Generative Artificial Intelligence (GenAI) in the Manufacturing Sector

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Abstract. The initial implementation and subsequent adoption of novel technologies are contingent upon numerous factors. It is imperative for organizations to closely evaluate these aspects. This paper aims to develop a research model utilizing the diffusion of innovation (DOI) theory, technology-organization-environment (TOE) framework and innovation resistance theory (IRT) to ascertain the key factors influencing the initial acceptance and continued adoption of generative artificial intelligence (GenAI) within the manufacturing sector. The present study will utilize structural equation modelling to investigate the hypotheses, employing a quantitative survey methodology.

Keywords: Adoption of technology · Digital technology · Generative artificial intelligence · GenAI · Diffusion of innovation (DOI) · Technology-organization-environment (TOE) · Innovation Resistance Theory (IRT)

1 Introduction

According to Kausiak (Kusiak, 2020), during the course of the last 30 years, the manufacturing industry has extensively incorporated various technological tools such as enterprise resource planning (ERP) (Duplaga and Astani, 2003; Masini and Van Wassenhove, 2009), customer relationship management (CRM) (Teng et al. 2007; Zandi and Tavana, 2011), and software-as-a-service (SaaS) (Kung et al. 2015) into its operations. Nevertheless, due to the ramifications of the COVID pandemic, the sector has experienced a substantial transformation that facilitates the incorporation of various innovative technologies. In light of recent events, it is imperative for manufacturing enterprises to enhance their resilience in order to effectively navigate unforeseen disruptions. The incorporation of advanced digital technologies such as Artificial Intelligence (Chien et al. 2020; Dwivedi et al. 2021; Zeba et al. 2021), machine learning (Kusiak, 2020;

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Meng et al. 2020), robotics (Ballestar et al. 2021; Zanchettin et al. 2015), blockchain (Ghimire et al. 2022; Kasten, 2020) among others, has significantly influenced the trajectory of manufacturing. The utilization of these contemporary technologies is expected to contribute to the enhancement of design, optimization and streamlining of production processes, waste reduction, productivity augmentation, and improvement of customer experience.

In recent times, there has been a notable surge in academics as well as practice attention towards the concept of generative artificial intelligence (GenAI) across a number of disciplines, including business and management (Reshetnikova and Mikhaylov, 2023; Wach et al. 2023). The global generative AI market is anticipated to rise from USD 11.3 billion in 2023 to USD 51.8 billion by 2028 according to Markets and Markets study (Naim S, 2023). GenAI combines machine learning, natural language processing (NLP), image processing, and computer vision to prodgeuce new content automatically through input data. In the present day, organizations operating in the manufacturing sector are actively exploring the utilization of GenAI tools, such as DALL-E and ChatGPT, with the aim of enhancing efficiency and productivity within the highly competitive market. An example of GenAI is the utilization of Generative Adversarial Networks (GANs) in the field of automotive design may be observed in the practices of the Toyota Research Institute (TRI). According to (Mast, 2023), the incorporation of engineering limits into the initial concept sketches serves to optimize the iterative process towards the development of the final design. Design alternatives are produced by GenAI using algorithms to maximize material efficiency and structural strength. Additionally, machine productivity and performance may be tracked via GenAI, and errors can be found and fixed. Gen AI can assist in the preparation of assembly shop floor error logs that can assist management in making informed decisions. By analysing consumer behaviour and market disruptions, GenAI can be used for sales forecasting on the supply chain management side. End point customers service and interaction can be improved using GenAI by foreseeing sentiment, patterns, and trends. Mercedes-Benz vehicles utilize the ChatGPT model provided by the Microsoft Azure OpenAI service, which facilitates user interaction with the chatbot across a range of conversational contexts (Mani, 2023). BMW has lately announced its intention to employ GenAI in order to provide customized driving experiences. According to Mani (Mani, 2023), Based on Gartner's analysis, it is projected that GenAI would account for 10% of the total volume of generated data by the year 2025 (Dilmegani C, 2023). In a manufacturing set-up, GenAI can improve customer support through the use of chatbots, can identify production defects (Chui et al. 2022). Despite the numerous beneficial effects associated with the adoption of new technologies, it is important to acknowledge the potential negative consequences that may also arise. Lack of quality control, misinformation, and algorithmic bias during GenAI adoption have been accountable for the negative effects on the industry (Wach et al. 2023). Moreover, Using GenAI may raise issues such as copyright and legal issues, data privacy violations, data provenance, and exposure to hazardous information (Lawton G., 2023). Because AI chatbots are widely utilized in customer service applications (Dwivedi et al. 2021) including reservations, enquiries, and complaint management, they may increase the danger of unemployment (Mannuru et al. 2023). So when deploying GenAI, it is crucial

to thoroughly examine additional factors such as data privacy violations, the reinforcement of pre-existing biases, and the impact on workforce roles and morale (Lawton G., 2023).

Overall, this study aims to examine the determinant factors for initial acceptance and continued adoption of GenAI in manufacturing sector. In our study, the model is built in two stages. The first stage looks at the underlying factors that contribute to the first acceptance of GenAI in manufacturing sector through the lens of diffusion of innovation (DoI) Theory. The second stage additionally investigates the variables that may influence the continued adoption by using technology-organization-environment (TOE) framework and innovation resistance (IRT) theory.

The key to initial implementation of any new technology is that both the consumer and the technology adopter must regard the concept as novel or innovative. Five essential characteristics of innovation in the context of technology initial implementation are outlined in Rogers' classic DoI theory (Rogers Everett, 1995). Those characteristics are relative Advantage, compatibility, complexity, Trialability and observability. Although all five characteristics are significant, it has been found that the first three— relative advantage, compatibility and complexity—are the best at explaining how technology adoption will spread across different fields of study (Prasad Agrawal, 2023). Therefore, in order to establish whether or not the manufacturing industry will be able to implement GenAI, the study intends to examine the relative advantages, compatibility, and complexity of GenAI. In this study, we attempt to analyse the following research question based on the DoI theory:

Research Question 1: What are the antecedents and driving elements for initial implementation of GenAI in manufacturing sector?

Adopting new technologies is difficult in terms of organizational acceptance, carrying out change requirements, and skill alignment with available resources. It is crucial to evaluate the team's ability to handle the adoption of new technologies as well as infrastructure readiness. Moreover, it is important to integrate the new technology adoption with the existing systems. To evaluate the firm-level adoption of various information related and technology products and services, Tornatzky and Fleischer (Tornatzky and Fleischer, 1990) created the Technology-organization-environment (TOE) framework. Multiple authors have tested different aspect of the TOE framework for the adoption of various technologies because it has become a widely accepted theoretical perspective on IT adoption (Awa and Ojiabo, 2016; Gangwar et al. 2014). Based on TOE framework we try to check the overall readiness of organization through the below research question:

Research Question 2: What is the organizational level readiness from social, technological, and environmental perspectives for continued adoption of GenAI in manufacturing set-up?

The GenAI's initial users throughout the initial implementation and continued adoption phase are the employees who are deploying it. Therefore, it is imperative that employees embrace GenAI. Resistance is a normal reaction to the adoption of new technology because it necessitates a change in working methods and prior behaviours (Ram, 1987). Individuals' propensity to resist change may also be a significant factor in delaying the adoption of new technologies (Migliore et al. 2022; Talke and Heidenreich, 2014). During the early adoption of any new technology, employees frequently

worry that the digital revolution would render their professions obsolete(Rotman, 2013). Psychological factors such as personality, emotions, motivation and attitude of employees plays an important role in continued adoption of new technology(Gerli et al. 2022; Migliore et al. 2022; Roberts et al. 2021). Moreover, there are functional barriers such as compatibility, misuse of technology and performance risk issue(Antioco and Kleijnen, 2010; Migliore et al. 2022). Based on the innovation resistance theory, the following research question is formulated:

Research Question 3: What are the impacts of resistance of employees and end users to GenAI adoption?

The subsequent section of the paper presents a comprehensive overview of the theoretical underpinnings of the research and a meticulous examination of the existing body of literature pertaining to the adoption of technology, with a particular focus on GenAI.

2 Literature Review

Due to its recent emergence, there has been a limited amount of extensive research conducted on the subject of GenAI. A considerable proportion of the literature examined in this study pertained to the domains of research, teaching, and education (Baidoo-Anu and Owusu Ansah, 2023; Noy and Zhang, 2023; Peres et al. 2023). Previously the domain of artificial intelligence in the manufacturing sector has generated a substantial body of scholarly works (Arinez et al. 2020; Chien et al. 2020; Li et al. 2017; Zeba et al. 2021). The use of GenAI, such as ChatGPT, according to Badani et al. (Badini et al. 2023) can result in significant time and material savings in the adaptive manufacturing space. GAN, a well-known framework for approaching GenAI, is already utilized in manufacturing for surface inspection, condition monitoring, and quality control (Kusiak, 2020). Wang et al. (Wang et al. 2023) in their discussed about the prospect of applying industrial generative pre-trained Transformer (Industrial-GPT) in manufacturing sector to improve productivity. Nevertheless, there is a scarcity of literature regarding the implementation and impact of GenAI within the manufacturing industry. This study aims to examine the determinants influencing the adoption of GenAI within the Manufacturing industry.

3 Conceptual Framework and Hypothesis Development

The conceptual model has been divided into two distinct phases as shown in Fig. 1. Stage 1 encompasses the identification and incorporation of pertinent aspects that are crucial for the successful implementation of GenAI. The study employed the Diffusion of Innovations (DOI) theory to ascertain the determinants that impacted the initial implementation of GenAI. These determinants encompassed the relative advantage, compatibility, and complexity associated with the GenAI. The post-implementation stage, which is covered in the next phase, includes important elements that have an impact on the continued adoption of GenAI. Drawing upon the theoretical framework of technology-organization-environment (TOE) theory, the present study is trying to identify key characteristics that exert influence on the sustained adoption of GenAI. These elements include technology readiness, absorptive ability, and competitive pressures.

This study also employs the innovation resistance theory to examine the factors that hinder the continuous acceptance of GenAI. Specifically, the research highlights functional obstacles and psychological barriers as key factors that negatively impact the adoption of this innovative technology.

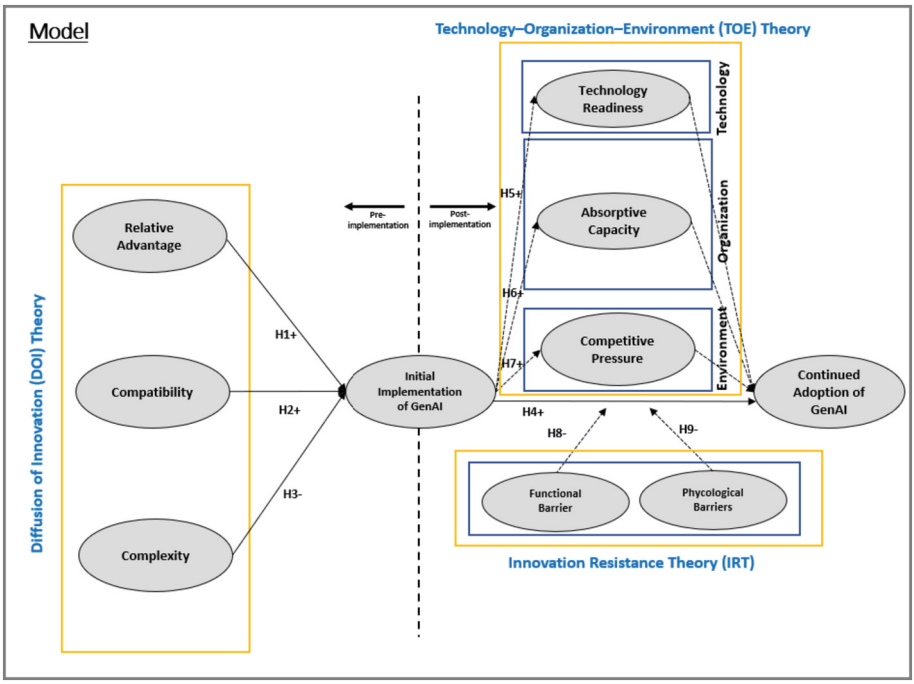

Fig. 1. Conceptual Framework

3.1 Diffusion of Innovation (DOI) Theory

Technology selection plays a significant impact in various domains. The term "relative advantage" refers to the perceived benefit above what is now used that the new technology will replace or supplement (Sharifani et al. 2022). According to earlier research, GenAI's relative benefit is not always considerable and may not always be the main factor in its adoption, making it a potentially insignificant discriminator (Prasad Agrawal, 2023). But again the relative advantage of generative is highlighted by other studies (Chui et al. 2022). The capacity to acquire knowledge about the fundamental distributions and patterns present in a dataset confers a notable advantage to GenAI in comparison to other technologies. So out study tries to check the relative advantage of GenAI which adopted in manufacturing set up. The notion of compatibility pertains to the degree of alignment between a novel technology and the many aspects of the user and the specific context in which it is intended to be employed (Karahanna et al. 2006). Numerous research have consistently illustrated the significance of compatibility as a reliable predictor of

technology adoption outcomes (Agarwal and Prasad, 1997; Karahanna et al. 2006). It is crucial to ascertain the feasibility of integrating GenAI models with pre-existing systems. Complexity can be described as the degree to which a developing technology is perceived as being relatively challenging to comprehend and utilize. According to the study conducted by (Sharifani et al. 2022), One of the primary advantages of contemporary GenAI is in its inherent simplicity and intuitive nature. The primary focus of our initial hypothesis is to examine the impact of the three criteria on the early adoption of GenAI.

H1(+): Relative advantage of GenAI leads to initial implementation of GenAI
H2(+): Compatibility of GenAI leads to initial implementation of GenAI
H3(-): Complexity of GenAI hinders initial implementation of GenAI

3.2 Transition from Initial Implementation to Continued Adoption

According to earlier studies, continued use is not just an extension of the initial technology adoption, and these two behaviours are not always influenced by the same factors (Fishbein and Ajzen, 2005; Setterstrom et al. 2013). For the introduction of new technology to continue its adoption, it is essential to comprehend the observed changes in attitudes and behaviours of consumers over time from an organizational perspective as well (McLean et al. 2020). The incorporation of novel information technology within organizations serves as a prime exemplification of organizational change in practice. The topic of continuing technology adoption after initial acceptance has been the subject of a great deal of research (Liao and Lu, 2008; Obal, 2017; Sun, 2013). According to Lippert and Davis (Lippert and Davis, 2006), the implementation of organizational reform is necessary in order to foster a company culture that is receptive to the adoption of new and developing technologies. There often exists a continuous disparity between the value generated by technology firms and their ability to utilize it efficiently. According to Leonard-Barton and Kraus (Leonard-Barton and Kraus, 1985), it is widely recognized that businesses with similar functions exhibit diverse behaviors and performance outcomes when implementing comparable new technology (Barley, 1986). Hence, despite the potential for increased chance of sustained adoption, the present hypothesis aims to assess the transition from initial implementation to effectiveness continued adoption of GenAI.

H4(+): Initial implementation of GenAI leads to continued adoption of GenAI

3.3 Role of Technology–Organization–Environment (TOE)

In comparison to other adoption models like the theory of planned behaviour (TPB) and theory of reasoned action (TRA), TOE model is widely used in technology adoption context as it gives a holistic overview of adoption of technologies and moreover it is free from firm-size and industry specific restrictions (Gangwar et al. 2014; Oliveira and Martins, 2010). One of the key components for successful continued technology adoption is technology readiness. The term "technology readiness" was developed in certain literature to characterize how close a technology is to being used operationally (Uren and Edwards, 2023). Technology readiness is the technical capacity of the company to enable the adoption of new technologies. It considers both the technical infrastructure's

structural element and the human resources' skill set in adopting the new technology such as GenAI (Oliveira et al. 2014). Businesses are more likely to derive business value from a technology adoption if they demonstrate technological readiness (Pan and Jang, 2008).

Absorptive capacity is one of the most widely construct in organizational research (Lewin et al. 2011). The term "absorptive capacity" refers to a firm's capability to acquire, comprehend, value, assimilate, and utilize the information present in the environment in order to achieve commercial objectives (Cohen and Levinthal, 1990). It can be one of the critical factors in determining continued adoption of GenAI. The absorptive capacity consists of three forms of learning for the organization: exploratory learning, transformative learning and exploitative learning (Gomez and Vargas, 2009). Organizations can better comprehend the advantages of implementing GenAI with the use of exploratory learning. Organizations can benefit from transformative learning by integrating their current systems with GenAI. Exploitative learning can assist organizations in successfully implementing GenAI.

Competition is often thought to have a favourable impact on technology adoption (Lee, 2004). Competitive pressure put pressure on top management to search for new alternative in terms of technology adoption to improve productivity (Gangwar et al. 2014; Kretschmer et al. 2012; Majumdar and Venkataraman, 1993). But there is a negative side of the competitive pressure as well. According to an IDC survey, executives are hesitant to adopt GenAI due to a lack of expertise and nascent technology. More than half of leaders, however, claim that they are under intense or significant pressure to use GenAI in the upcoming year (Torres R., 2023). Therefore, it is crucial to assess how competitive pressure affects GenAI adoption. Using the TOE model as a lens, this study tries to investigate the progression of GenAI from its original deployment through its continued adoption. This study examines the mediating role of Technology–Organization–Environment in relation to Initial implementation and Continued Adoption.

H5(+): Technology readiness mediates the relationship between initial implementation and continued adoption of GenAI
H6(+): Absorptive capacity mediates the relationship between initial implementation and continued adoption of GenAI
H7(+): Competitive pressure mediates the relationship between initial implementation and continued adoption of GenAI

3.4 Role of Innovation Resistance Theory (IRT) Elements

In this study we have considered both the end users as well as the organizational employees as the initial consumers of GenAI. As already mentioned in many literatures, consumer intention to adopt technology may be hampered by unfavourable conditions (Heidenreich and Handrich, 2015; Migliore et al. 2022). Employees in an organization may be reluctant to accept GenAI due to technical challenges, a lack of understanding of GenAI, fear of job loss, and other factors. IRT (Ram, 1987) states that any use of new technology results in changes for consumers and that resistance to change is a natural reaction that must be addressed during the early phases of adoption. The prior work has explored functional and psychological barriers as two distinct types of barriers (Dwivedi et al. 2023; Kaur et al. 2020; Migliore et al. 2022). Functional barriers appear if consumers

believe the innovation will result in major changes due to new technology adoption. Functional barriers may cause due to incompatibility of GenAI with existing technologies. Psychological conflicts resulting from a customer's beliefs are the main cause of psychological barriers (Joachim et al. 2018). Psychological barriers may cause due to the complexity of usage, perceived image of the consumers. In this study we tried to check the moderating role of Innovation Resistance Theory (IRT) elements on initial implementation and Continued Adoption.

H8(-): Functional Barrier moderates the relation between initial implementation and continued adoption
H9(-): Phycological Barriers moderates the relation between initial implementation and continued adoption

4 Research Methodology

A quantitative survey will be conducted. Main participants will be employees who have worked in GenAI implementation area from the IT Manufacturing sector. The scale and questionnaire have already been prepared (Refer appendix for details).

Appendix

Construct	Items	Details
Relative Advantage *Adopted from* (Oliveira et al. 2014)	RA1	GenAI allows you to manage business operations in an efficient way
	RA2	The use of GenAI services improves the quality of operations
	RA3	Using GenAI allows you to perform specific tasks more quickly
	RA4	The use of GenAI offers new opportunities
Compatibility *Adopted from* (Oliveira et al. 2014)	C1	The use of GenAI fits the work style of the company
	C2	The use of GenAI is compatible with current business operations
	C3	The use of GenAI will be compatible with existing hardware and software in the company
Complexity *Adopted from* (Oliveira et al. 2014)	CX1	The use of GenAI requires a lot of mental effort
	CX2	The use of GenAI is too complex for business operations
	CX3	The skills needed to adopt GenAI are too complex for employees of the firm

(*continued*)

(*continued*)

Construct	Items	Details
Initial Implementation of GenAI *Adopted from* (Bajpai and Misra, 2022)	IIG1	GenAI implementation aligned with business process
	IIG2	Adequate budget allocated for implementation
	IIG3	There is a successful technical capability support and IT support for GenAI implementation
	IIG4	Effective technical training and support provided for implementation of GenAI
Technology Readiness *Adopted from* (Oliveira et al. 2014)	TR1	The company knows how GenAI can be used to support operations and other functions
	TR2	Within the company there are the necessary skills to implement GenAI
	TR3*	Within the company there are the necessary tools and infrastructure to implement GenAI
Absorptive Capacity *Adopted from* (Ali and Park, 2016; Flatten et al. 2011)	AC1	Our management motivates the employees to learn more about GenAI
	AC2	In our company ideas and concepts on technologies are communicated cross-departmental
	AC3	Our employees have the ability to structure and to use collected knowledge on technology
	AC4	Our company regularly reconsiders technologies and adapts them accordant to new knowledge
Competitive Pressure *Adopted from* (Oliveira et al. 2014; Ranganathan et al. 2004)	CP1*	We track new technology initiatives of competitors and act accordingly
	CP2	Competitor information considered important for firm's decisions
	CP3	Our firm is under pressure from competitors to adopt GenAI
	CP4	Some of our competitors have already started using GenAI
Functional Barrier *Adopted from* (Chen et al. 2022; Migliore et al. 2022)	FB1	In my opinion, GenAI incompatible with existing work processes

(*continued*)

(*continued*)

Construct	Items	Details
	FB2	In my opinion, GenAI does not offer any advantage compared other technology
	FB3	I fear that GenAI will be mis-used in future
Phycological Barriers *Adopted from* (Chen et al. 2022; Migliore et al. 2022)	PB1	I am comfortable using the old existing technology rather than GenAI
	PB3	In my opinion, new technology is often too complicated to be useful
	PB4	I have such an image that GenAI is difficult to use
Continued Adoption *Adopted from* (Bajpai and Misra, 2022; Obal, 2017)	CA1*	My firm intends to continue using more GenAI system in future
	CA2*	My intentions are to continue using our GenAI system (where ever possible) rather than use any traditional software
	CA3	GenAI will help in improving the bottom line of organization
	CA4	GenAI will help in improving the customer satisfaction

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Sentence Generator for Hindi Language Using Formal Semantics

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Abstract. Natural Language Processing (NLP) is a specific field within artificial intelligence (AI) that focuses on enabling computers to understand spoken and written language in a manner similar to humans. Its practical applications include facilitating everyday activities such as texting, emailing, and cross-language communication. The demand for intelligent systems capable of reading text, listening to voice memos, and engaging in natural language conversations, even in languages like Hindi, has significantly increased in recent years.

This paper presents a random clausal hindi sentence generator, which generates simple, compound, and complex sentences. This tool is particularly useful for students studying on online platforms as it provides a variety of exercises to practice on and learn about clauses. The sentence generation process begins with the generation of simple sentences and gradually progresses to compound and complex sentences. The method employs approximately one hundred verbs to introduce randomness, along with three to four conjunctions and objects that are closely associated with the verbs. This approach ensures that the generated sentences are both syntactically and semantically meaningful.

Keywords: Natural Language · Sentence · POS tagger · Verbs · Nouns · phrases · grammar

1 Introduction

In recent times, there has been a notable rise in the demand for intelligent systems capable of analyzing text and voice notes, while also engaging in natural language conversations, including languages like Hindi. This increasing interest has given rise to Natural Language Processing (NLP), a field that amalgamates computational linguistics with statistics, machine learning, and deep learning models (Kulkarni and Pai, 2019). By harnessing these technologies, computers are now able to comprehend human speech presented as text or audio data, not only understanding the content but also the intentions and emotions of the speaker or writer.

Developing a Hindi virtual exercise for identifying clauses is of paramount importance as it facilitates language proficiency, enhances cultural relevance, and enables personalized learning experiences. By aiding learners in comprehending sentence structure

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and nuances, this exercise strengthens their linguistic skills and fosters effective communication in Hindi. Moreover, it caters to the unique needs of Hindi-speaking students, making language education more engaging and tailored to their context. The interactive nature of virtual exercises also allows for better progress tracking and instructional adaptation by educators. Ultimately, this project holds great significance in advancing language education and empowering individuals to excel in Hindi communication.

This advancement has led to the creation and widespread usage of NLP applications, such as text summarization (Manome et al. 2018) and dialogue generation. Within the realm of natural language processing, sentence generation emerges as a foundational challenge. Many efforts have been dedicated to crafting a robust approach; however, the generation of sentences that are both grammatically accurate and semantically meaningful remains an ongoing hurdle.

A crucial field of study in the field of computational linguistics is syntax analysis. Machine translation, storyline construction, problem-solving, information retrieval, and information extraction are important applications of semantic analysis in computational linguistics.

The practical applications of a sentence generator are outlined as follows:

- Sentence generation can be applied to produce Hindi exercises across diverse topics for students on platforms like Online Labs (OLabs) for School Lab Experiments, hindi grammar.org, Perfect Hindi Grammar, first-hindi, and more.
- A sentence generator can be employed to automatically respond to emails or messages. For personalized responses, a tailored sentence generator would be essential. **Sample Heading (Third Level).** Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.
- The sentence generator finds practical application as a dialogue generator within human-machine systems.
- Utilizing the sentence generator, it's feasible to craft narratives based on specified subjects. Users can designate topics, ensuring the generated content remains relevant to their chosen theme. Personalized writing style cues can be extracted from texts penned by the specific author to capture their distinctive voice.

An illustrative instance of a sentence generator's utility can be observed on the platform Olab (http://www.olabs.edu.in/). Here, students gain access to virtual labs. Within the Hindi Grammar segment of this website, there's a clause exercise showcasing the sentence generator's capabilities. It generates novel phrases with each iteration. Notably, the generator excels at producing accurate basic, complex, and compound sentences in the Hindi language.

The paper at hand delves into a methodology for composing simple, compound, and complex sentences in Hindi. This is achieved by leveraging a series of grammatical rules rooted in Hindi literature. The primary objective of this approach is to construct sentences that excel both syntactically and semantically.

Throughout the development phase of the sentence generator, an array of methodologies and approaches underwent testing. Initially, POS (Parts of Speech) taggers were employed. Different POS were organized into files, and Python code was harnessed to incorporate preferred sentence structures – encompassing complexities like compound or

complex sentence forms. This method involved appropriately tagging words and arranging them in the correct sequence to shape coherent sentences. However, English grammar rules proved more adept at generating precise sentences. This specific methodology is discussed in more detail in subsequent sections.

2 Background and Related Work

Researchers have explored and developed a range of approaches to create a more reliable sentence generation method. This section provides an overview of the current literature on the subject.

Semantic parsing methods, such as Combinatory Categorial Grammar (CCG) presented in Li et al. (2017), utilize logical meaning representations to construct sentences using the Seq2Seq format. Grammar-based sentence generation has been experimented with in other languages as well, such as the Sanskrit Sentence Generator (Martin, 2018), which generates semantically correct sentences using Panini's grammar rules. Although this grammar-based approach to sentence generation has proven to be robust, it has not been extensively explored. Therefore, this paper presents an experiment on generating sentences using grammar for the Hindi language.

The exploration of sentence generation in Hindi has a notable historical background, tracing its origins to rule-based techniques in the early phases of computational linguistics. These initial endeavors primarily relied on manually crafted grammatical rules, which had inherent limitations in handling intricate language structures and producing natural-sounding sentences.

Early approaches to Hindi sentence generation predominantly employed rule-based methods, encompassing grammatical and syntactical rules. However, these systems often struggled to achieve fluency and were challenged in capturing the nuanced aspects of the language.

The emergence of Statistical Machine Translation marked a significant turning point in Hindi sentence generation. SMT systems harnessed parallel corpora and statistical models to generate translations. While effective for translation tasks, SMT-based systems encountered difficulties in producing contextually relevant sentences.

The introduction of Neural Machine Translation heralded a transformative era for Hindi sentence generation. NMT models, particularly sequence-to-sequence architectures, exhibited substantial improvements in generating fluent and contextually accurate Hindi sentences. Transformer-based models such as the Transformer and BERT have played pivotal roles in this progress.

Challenges in Hindi Sentence Generation. Hindi boasts a morphologically rich structure with intricate inflections, genders, and cases. The flexibility of word order in Hindi poses complexities in generating grammatically sound sentences. Scarce availability of Hindi training data, particularly in specific domains, can hinder model performance.

Hindi sentence generation in the realm of NLP has evolved considerably from rule-based methodologies to data-driven neural models. These advancements have significantly improved the quality and contextual relevance of generated sentences. Challenges remain, but ongoing research and innovations continue to expand the horizons of possibilities within this field.

3 Proposed Methodology

Grammar consists of five levels: sentence, clause, phrases, words, and morphemes (Perera and Nand, 2017). The proposed methodology for automatic generation of clausal sentences is based on the rules of Hindi grammar, which are utilized in sentence formation. Initially, a dataset of sentence components such as nouns, verbs, determiners, and conjunctions is created. Since some categories have broad applications and can be used interchangeably depending on the sentence's meaning, the dataset is generated by grouping words that can be used interchangeably, such as names of male/female human beings. One of the syntactic rules for clause formation is Subject + Object + Verb, where the subject and object are nouns, and the relationship between the verb and object plays a crucial role in determining the sentence structure.

There are certain objects which can be used with their respective verbs such as all eatable items are used with verbs: "खाता है, खाता था, खाने वाला है,"Thus, the repository of nouns is to be divided into further groups depending upon the verbs which are mentioned in verb dataset like:

- eatable items (used with 'खा'verb)
- drinkable items (used with 'पी'verb)
- various place list (used with 'जा'verb)
- list of shows and movies (used with 'देख'verb)

A total of 25 repositories consisting of various separate data of names, verbs and objects based on verbs were made.

A simple sentence contains a single clause whereas if a sentence contains more than one clause it can either be compound or complex sentence. Each of these types of sentences have their own syntactic rules. The rules explored in this paper are as follows:

For Simple Sentences

Subject + Object + Verb

For Compound Sentences

Subject1 + Object1 + Verb1 + Conjunction + Subject2 + Object2 + Verb2 + The conjunctions which are used in this rule are: और , पर , लेकिन क्योंकि, इसलिये

For Complex Sentences

Subject1 + Object1 + Verb1 + Conjunction + Pronoun + Object2 + Verb1

Conjunctions used in this rule are: और , पर , लेकिन क्योंकि, इसलिये

Using the four rules mentioned above, with the repository created, large number of clausal sentences can be created. Figure 1,2 and 3 shows some of the sample sentences using this method.

Lets explain this methodology with example:

Rule 1.1: For Simple Sentences

Rule: Subject + Object + Verb

Example: Subject: "राम"(Ram)

Object: "गाना"(song)

Verb: "गाता है"(sings)

Sentence: "राम गाना गाता है।"(Ram sings a song.)

In this simple sentence, we have the subject "राम"(Ram), the object "गाना"(song), and the verb "गाता है"(sings) following the Subject + Object + Verb structure.

Rule 1.2: For Compound Sentences

Rule: Subject1 + Object1 + Verb1 + Conjunction + Subject2 + Object2 + Verb2

Example for independent clause (प्रधान उपवाक्य)

Subject1: "राम"(Ram)

Object1: " गाना "(a song)

Verb1: " लिखता है"(writes)

Conjunction: "और"(and)

Subject2: " सीता "(Sita)

Object2: " गाना "(sing)

Verb2: " गाती है"(a song)

Sentence: "राम गाना लिखता है और सीता गाना गाती है ।"(Ram writes a song, and Sita sing a song.)

This is a compound sentence formed by combining two simple sentences using the conjunction "और"(and).

Rule 1.3: For Complex Sentences

Rule: Subject1 + Object1 + Verb1 + Conjunction + Pronoun + Object2 + Verb1

Example: Subject1: "सीता "(Sita)

Object1: " गाना "(a song)

Verb1: " गा रही थी"(was singing)

Conjunction: "लेकिन"(but)

Pronoun: " वह "(she)

Object2: " असमर्थ थी "(was incapable)

Sentence: " सीता गाना गा रही थी, लेकिन वह असमर्थ थी"(Sita was singing a song but she was incapable.)

This is a complex sentence where the conjunction "लेकिन"(but) is used to contrast two actions performed by the same subject, "राम"(Ram).

Using these rules and the dataset of words and their associated verbs, a wide range of clausal sentences can be generated in Hindi, accommodating various sentence structures and meanings (Tables 1 and 2).

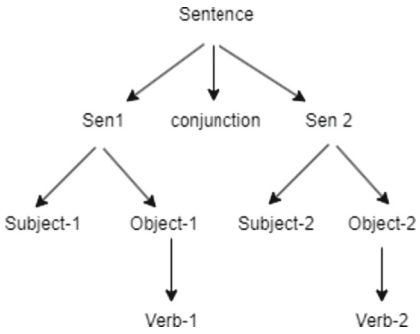

Fig. 1. Approach for Independent Clause Sentence

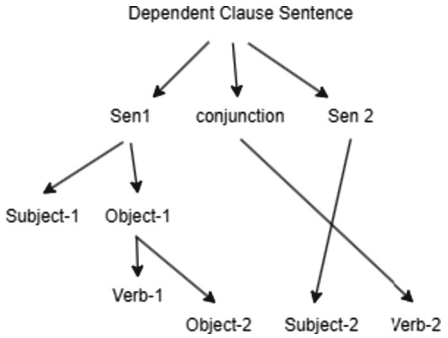

Fig. 2. Approach for Dependent Clause Sentence

Table 1. Corresponding Data in the file

Type of Objects	Words in Object file	Words in Verbs file
Cookable	1. हलवा	खाता है
	2. दाबेली	खाने वाला है
	3. रोटी	खा रहा है
Playable	1. क्रिकेट	खेल रहा है
	2. फुटबॉल	खेलता है
	3. बास्केटबाल	खेलने वाला है
Drinkable	1. कोल्ड कॉफी	पिता है
	2. चाय	पीने वाला है
	3. फ्रूट जूस	पीती है
	4. कोल्ड ड्रिंक	पीने वाली है
Watchable	1. टेनिस	देखती है
	2. ओलंपिक	देखने वाली है
	3. विश्व कप फाइनल	देखता है

4 Result and Evaluation Parameters

Table 2. Accuracy: Extrinsic Evaluation

Sr no	Types of sentences generated	Average Accuracy
1	Simple	96%
2	Compound	92%
3	Complex	87%

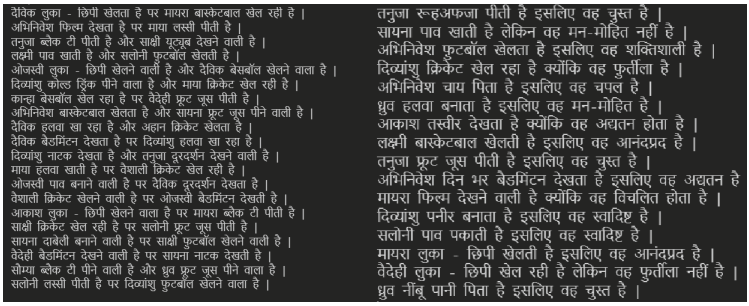

Fig. 3. Generated Independent & dependent clause sentence

5 Conclusion and Future Work

By utilizing the formal semantics of the Hindi language, this work was able to produce meaningful basic, compound, and complicated phrases in Hindi. To guarantee the logical validity of the generated sentences with a high degree of precision, verbs and their associated objects were grouped together. This method produced sentences that followed the guidelines for simple, compound, and complicated sentence structures.

A meaningful sentence generator for the Hindi language offers diverse advantages for project developers. It automates content generation, ideal for chatbots, content creation, or social media posts. It aids language learners by providing a continuous stream of practice sentences. In the field of machine learning, it helps augment datasets and test algorithms. For researchers, it streamlines testing and evaluation processes. Customizable for specific domains or styles, it saves time and supports creative writing projects. Additionally, it contributes to language preservation by creating a repository of sentences, phrases, and idioms in Hindi.

In the future, the range of combinations can be broadened to generate a wider range of sentences. It's crucial to remember, though, that adding more templates could also make it more likely that you'll make semantic mistakes. Future enhancements will include removing these barriers. Additionally, using the same concept, a phrase generator for Marathi and Sanskrit can be created. The sentence generator can be modified to generate sentences in Marathi and Sanskrit while keeping the methodology's coherence by drawing on the formal semantics of the Hindi and Sanskrit languages (Bharati et al. (1996).

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Human Resource Analytics: Leveraging Machine Learning for Employee Attrition Prediction

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Abstract. Organizations in the 21st century face a major challenge in the form of employee attrition. Due to increasing prevalence of highly skilled workers, amidst the competition among organizations to secure talented employees, finding effective employee satisfaction solutions has become more important than ever. Developing a strong workforce for global competition requires employees in an organization should see themselves as important and indispensable members of the group. In order to predict which factors, contribute to an increase in churn rate, companies must invest in powerful predictive mechanisms. A certain degree of accuracy may enable the organization to identify these factors and eliminate them or, in the worst case, decrease their impact. With machine learning, large datasets can be analysed more efficiently to gain meaningful insight into their complexity. As machine learning platforms have grown, human resource analytics have risen to help managers make some of the most difficult decisions. Organizational ecosystems have improved, resulting in profit growth, stronger organizational ecosystems that have never been seen before a decade ago. Over the top Fortune 500 companies, machine learning algorithms are now standard practice in human resource departments, and similar solutions are rapidly being introduced by other organizations to improve the satisfaction of employee. The best efficacious machine learning algorithms namely Logistic Regression, K Nearest Neighbour, Random Forest, Adaboost and Gradient Boosting for predicting voluntary turnover are analysed in this work to explain the underlying causes of employee attrition.

Keywords: Machine Learning · Feature Selection · Classification · Employee attrition Prediction

1 Introduction

A human resource department faces a lot of challenges as a result of employee attrition. By nurturing talent within the organization, organizations can operate more efficiently (reduced costs and effort), as well as provide their customers and other stakeholders with value added services.

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It is inevitable that a company will have its ups and downs, but what happens when the downs become too frequent or too severe? An employee survey was conducted by IBM to better understand employee attrition and performance. Cloud computing, artificial intelligence, and enterprise software are a few of the products and services IBM offers. To keep up with changing customer demands, IBM has shifted its focus to newer areas of business, such as cloud computing and artificial intelligence. An employee survey was conducted by IBM during this shift to determine potential changes.

This study analyses IBM's employee attrition and performance data from their survey to identify potential problems or areas for improvement. A summary of the findings is presented in the work, along with recommendations based on the findings. IBM's employee attrition and performance analysis are relevant to the current business environment in that it provides insight into some of the challenges IBM has been facing with its Human Resources (HR) as well as how they can be overcome, which other organizations in the industry can use to improve their operations. The analysis offers insights into how IBM employees feel and potential solutions to keep them engaged and happy at work.

This data was sourced from Kaggle. Data refers to IBM's employee attrition and performance. Machine learning is the underlying statistical technique in this work, which uses Python as its coding language. Predictive models are built using it primarily to make better predictions.

Several supervised algorithms are used for classification, including "Logistic Regression", "Nearest Neighbours Algorithm", "Random Forest", "Adaboost", and "Gradient Boosting". For employee attraction prediction, accuracy, precision, recall, and F1 score are measured according to the implemented work.

A huge amount of money is spent by many organizations to hire talented people over different domain areas in order to reduce the demand within their individual workforces. Although the demand appears partially as a result of the expansion of the organizations themselves, attrition rates are the major factor driving it. There are many processes that companies utilize to help their employees grow as they contribute their wisdom and expertise to the company's development. Rivalry between organizations as well as the growing demand for skilled talent often led workforce to seek elevated potential elsewhere. During the last decade, attrition rates have risen exponentially due to the grow of technology industries and start-ups that require well-versed talent who can perceive and carry out their respective fields.

Due to high attrition rates, the human resource department in a company has continuously faced significant challenges. The decision to leave a company is influenced by several factors other than the company's environment. Inspite of the organization's efforts to create an agreeable and Learning ecosystem, the reduction of employee turnover cannot be achieved by merely minimizing it. In order to prepare themselves for the unforeseen future, organizations have developed innovative methods to realize the causes of employee churn and predict their workforce turnover in the years to follow. It is imperative for organizations to build exceptional workforces that have the lowest attrition rates in order to gain a competitive advantage on the global stage.

1.1 Machine Learning and HR Analytics for Attrition Prediction

Researchers have identified a wide variety of factors that contribute directly or indirectly to employee attrition rates. The presence of societal indicators "age", "gender", "education", "ethnicity", and "marital status" may help predict voluntary employee turnover. Among the other characteristics that may have an effect are "job satisfaction", "salary", "growth potential", "supervision", "advancement", "working conditions", "recognition", and "burnout". There are two perspectives on the factors: organizational and individual. To increase employee retention rates, each of the factors has been thoroughly studied. In recent years, organizations have been able to accurately predict many human resources-related factors with the rise of machine learning algorithms. ML can therefore be applied to attrition rate to determine predictive performance and better understand the factors leading to attrition rate increases.

1.2 Problem Definition

Employee turnover: Can HR analytics help predict it?

Over the years, companies' attrition rates have been extensively researched. However, there has been little progress made in reducing attrition to below a certain percentage. Attrition rates differ greatly across geographies as well. It is estimated that more than 15% of UK employees resign each year. Across industries and sub-geographies of the country, this differs greatly. Among organizations competing for talent, the private sector has the highest turnover rate. In the private sector, turnover varies according to the type of industry. Construction and media have the lowest turnover rates, while IT, retail, and catering have the highest. Across multiple regions, public sector companies have the lowest turnover rate. Among public sector companies, accountancy, legal, and education have the lowest attrition rates. In different industries, organizations track turnover data on a monthly or quarterly basis. Organizations calculate voluntary turnover rates and determine whether they are acceptable or unacceptable. For this reason, organizations need to reduce observed attrition scenarios. Particularly when competing in global organizations.

The objective of this research work is to use optimal algorithms to improve accuracy in predicting the most influencing factors that decrease employee attrition rates. Organizations have successfully used machine learning algorithms to find and predict based on optimal models based on patterns detected in datasets. The objective of this analysis is to ascertain the optimal attributes that lead an employee to leave an organization based on factors such as low salary, lack of career mobility, high levels of stress, inability to balance work and life, inability to trust supervision, inability to match employees with jobs, a lack of clarity of role, a lack of proper feedback, and unclear performance goals. A company's employee turnover rate is the focus of this research. Churn rate at any organization can be predicted by matching the patterns between parameters affecting employee attrition. Identifying the primary variables that influence employee attrition is essential to predicting churn rate.

1.2.1 Aim

To predict employee turnover using HR analytics.

1.2.2 Research Questions

Using Machine Learning, how can we predict employee attrition?
What are the most important factors that affect employee turnover?
Who will leave, when will they leave, and why will they leave the organization?
What is the attrition rate? Is it high or low?
What are the factors affecting the attrition rate?
What recommendation can be provided to the management based on the analytics?

1.2.3 Objectives

General Objective.
To predict employee turnover in an identified organization by using qualitative and quantitative analyses.

Specific Objectives.
To analyse employee attrition data at a granular level and identify key trends and patterns with Exploratory Data Analysis.

To determine the employee profiles that are more prone to voluntary attrition within the organization by utilizing the machine learning techniques.

To employ machine learning techniques for the purpose of predicting employee retention within the organization (binary outcome: stay or leave).

1.2.4 Hypothesis Testing

Assumptions: Statistical analysis requires a large number of assumptions in each scenario.

Any significant relationship does not define causality in the Chi Square Independent Test.

The T-test has been consistently employed throughout the study.

Job Satisfaction vs Attrition.
Null Hypothesis: "There is no significant Relationship between Job satisfaction & Attrition".

Alternate Hypothesis: "There is significant Relationship exists between Job Satisfaction& Attrition".

Overtime vs Attrition.
Null Hypothesis: "Overtime and Attrition are independent of each other".

Alternate Hypothesis: "Overtime and Attrition are depended of each other".

Gender vs Attrition.
Null Hypothesis: "There is no significant relationship between Gender & Attrition".

Alternate Hypothesis: "There is significant relationship between Gender & Attrition".

1.3 Contributions Done

A mere 8% of companies can utilize HR analytics effectively to enhance managerial decision-making, according to Deloitte's 2016 Global Human Capital Trends report. Access to "HR analytics" is therefore of key importance for organizations. Two contributions are expected from this research. The first contribution of the research is to lay the foundation for state-of-the-art theories in "HR analytics" by analysing the radical nature of turnover by employee using Exploratory data analysis. The second goal of this research work is to cater a realistic methodology for analysing and measuring employee churn via Machine Learning Techniques. In this research, open-source languages, libraries, and platforms are used that are free to use. The ideas presented in this research can be adapted to fit the needs of small and medium businesses in order to decrease their attrition rate.

2 Literature Review

By deploying machine learning algorithms on large datasets and modelling them, organizations are able to find previously unpresented data points. Users can build any scale of model with the help of machine learning algorithms found on cloud platforms like Google, Azure, and Amazon. These algorithms are able to identify the primary factors that determine the results of target experiments. Large and small companies can now have accurate results that can lead to actionable results by tweaking the variables based on the operational requirements. A combination of these algorithms and artificial intelligence networks can be used by managers to predict an organization's expected turnover. It allows the organization to be prepared for any employee leaving the organization, by either finding a replacement or taking the necessary steps to ensure that the employee is satisfied.

Ramlall, S (2003) proposed an approach for increasing organizational competitiveness based on employee retention. This study examined the factors that most significantly influence employees' decisions to remain employed at a particular organization, and possible reasons for leaving. Furthermore, the study examined the benefits of retaining key employees and strategies to increase employee retention.

R.P. Babu (2004) discussed labor's insecurities and vulnerabilities within the new economic order, which consists of a typical norm of work and work arrangement. Among these insecurities are high employee turnover rates, increased work stress, and erosion of worker solidarity.

Based on a method by Goel, D and Thakur P (2006), the Indian offshoring industry is rapidly growing and the causes of attrition are often complex. It also explains how some industry participants are proactively addressing this problem, which threatens India's long-term sustainability as an offshore destination. This comprehensive insight focuses on attrition in Indian BPOs.

India's call center sector is growing rapidly, according to Budhwar, S. (2006). A case is then made for investigating human resource management (HRM) systems in Indian call centers. In this study, empirical data is analysed in two phases. In phase one, HRM systems are examined, while in phase two, attrition is addressed in Indian call centers. The investigation was conducted using a mixed method approach of in-depth interviews and questionnaire surveys. Mehta, A. and Mehta, N. (2005) performed an exploratory study of Indian outsourcing firms' human resource policies and practices.

Sachdeva, D., Mittal, R.K. and Solanki, R.B. (2010) conducted an importance-satisfaction analysis on select human resource practices using a structured questionnaire containing 54 pairs of importance-satisfaction items. In developing effective future strategies for KPOs, policy makers should be able to utilize the study's insights about employee perceptions and aspirations.

An investigation was conducted by Nanjegowda and Manjunatha in 2016 into the reasons for employee attrition in several software companies in the state of Karnataka. As part of this research, factor analysis was carried out to investigate the reasons of employee attrition in software companies, as well as factors that should be taken into account when addressing this issue.

Sze et al (2010) examined the factors influencing the intention to turn-over among young, well-educated professionals within the Malaysian service industry. These young employees showed a high tendency to switch jobs, according to the results. Both push factors (interference with work-family-lifestyle balance, poor relationships with co-workers, stressors at work, unsatisfactory supervisory relationships) and pull factors (better compensation, more interesting work, promotion opportunities, desire to return to academic studies) contributed to this decision.

Arvind Kumar and Meenakshi Kaushik (2013) suggested that organizations need to move from supporting their business strategy with HR as a transactional support role to partnering with them in their business strategy. BPOs in India should take steps to be aware of employee problems and try to solve them creatively.

A study by Srikant, A., and Tyagi, A. (2007) revealed that employee attrition is a crucial aspect of managing human resources in the BPO (Business Process Outsourcing) industry. Increased recruitment costs, loss of experienced employees, and disruptions in service delivery can result from high attrition rates.

3 Proposed Methods for Predicting Employee Attrition

Data analytics and prediction in large datasets have been greatly simplified by machine learning algorithms. The purpose of predictive analytics in human resources is to look for actionable information in data that can be used by managers to make important business decisions. This study involves Machine Learning, Data Mining, Modelling, and business knowledge. The field is often called HR analytics since it relates to the department that handles the management of human resources within an organization.

It is the responsibility on the subject of HR analytics department to investigate historical and current data to discover risks and opportunities in the organization. A HR analytics team often informs managers about HR issues they had no idea were problems. Furthermore, HR analytics helps companies make accurate predictions about the future of their human resources departments.

In the era of machine learning and predictive analytics, companies were able to draw real-time insights from a variety of departments, including Human Resources. Organizations were able to make better decisions and increase profits as a result. Today, HR analytics is gaining ground in most companies, allowing managers to realize informed decisions made by utilizing the data collected in their organizations. The use of predictive analytics has already helped some of the most vulnerable industries. A wide variety of industries have used it for predictive and preventative measures, such as the banking sector, manufacturers, and many others. As a result of its ease of deployment and numerous benefits, it is now gaining traction in human resource departments. Most organizations now focus their HR analytics on understanding churn rates and behavioural analytics of their employees.

The best algorithms for predicting the accuracy of data can be found by having a clear understanding of the machine learning methods. This research work is focus on six major supervised classifiers those proven to produce the desired results in accurately predicting employee turnover in organizations, despite the fact that hundreds of machine learning algorithms have been applied across multiple datasets for different industries. Moreover, these algorithms can be applied both to small and large datasets, and they have been deployed in numerous other instances. To find the most effective method for predicting attrition rate in similar datasets, we use IBM attrition datasets and explore all machine learning algorithms.

3.1 Description of the Dataset Used in This Study

Dataset used for the experiment can be found on Kaggle or IBM's website called IBM HR dataset, containing 1470 observations and 35 columns of variables. (IBM HR Dataset Excel file). It is not necessary to train the machine on all columns in the data set. An example would be the number assigned by the human resources department to each employee (which is just some number identification). There is only one value in every row of the Standard Hours, Over18, and Employee Count columns, so these columns do not provide any additional information. Columns such as these is deleted from the data set. Afterward, non-numeric columns are converted to numerical ones.

3.2 Data Preprocessing

Cleaning Data: Cleaning the data is the first step before exploring and predicting uncleaned data can lead to a poor model.

Missing Values: A table view of the dataset can be used to check variable by variable for missing values. Fortunately, the dataset does not contain any missing values, otherwise it would be necessary to replace them with the mean values of that variable.

Checking for Duplicates: There needs to be an elimination of duplicates to avoid any issues further. The data is adequate since there were no duplicates.

Constant Values: A variable with a constant value throughout the observation is of no use. Employee Over 18, Employee number, Employee count, and Standard Hours were removed as they have constant values.

A cleaned dataset with 1470 observations and 31 variables without missing values is now ready for EDA (Exploratory Data Analysis) and modelling (Fig. 1).

3.3 Exploratory Data Analysis

3.3.1 Visual Count of Employee Attrition

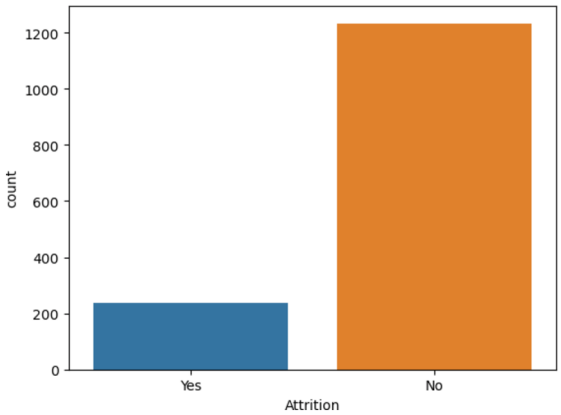

Fig. 1. Visual count of employee attrition with Count Plot

3.3.2 Attrition Department Wise.

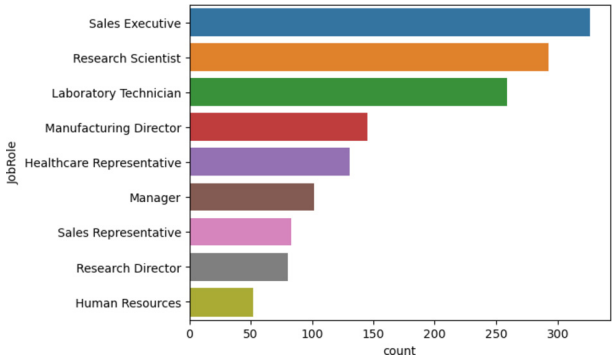

Fig. 2. Visualization of the Department wise attrition with Count Plot

Finding and Observations

- Employee Attrition is most in Sales Executive Department, Research Scientist and then Laboratory Technician.
- Least Attrition is noticed in Human Resources and Research Director Department (Fig. 2).

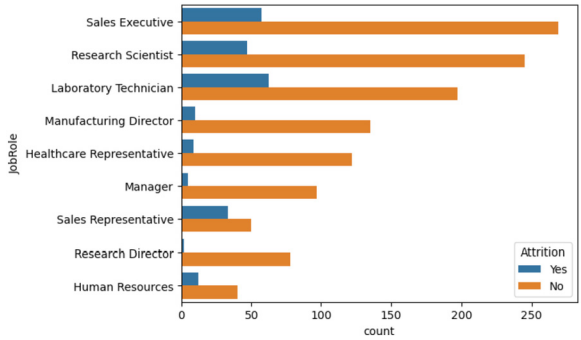

Fig. 3. Visualization of the job role & attrition with Count Plot

3.3.3 Attrition Based on Job Role

Finding and Observations

- A majority of employee jobs are sales executive, research scientist, and lab technician.
- Attrition is highest for Sales Executives, Sales Representatives, Laboratory Technicians, and Research Scientists.
- Researchers, managers, and healthcare representatives have the lowest employee attrition rates (Fig. 3).

3.3.4 Attrition Based on 'Job Role', and 'Hourly Rate'

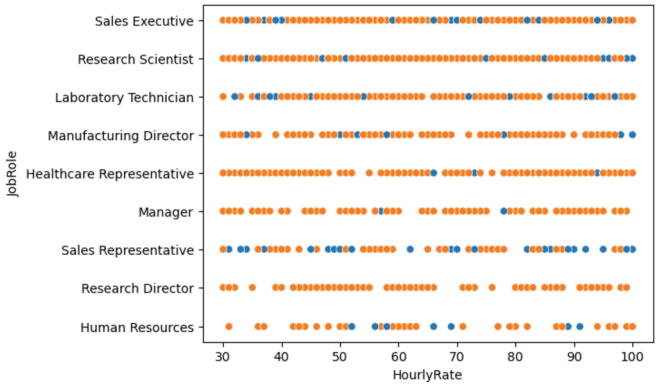

Fig. 4. Visualization of the 'Job Role' and 'Hourly Rate' with attrition with Scatter Plot

Finding and Observations

It is observed that the combination of a lower hourly rate and a job role is associated with a higher attrition rate (Fig. 4).

3.3.5 Attrition Based on Job Satisfaction

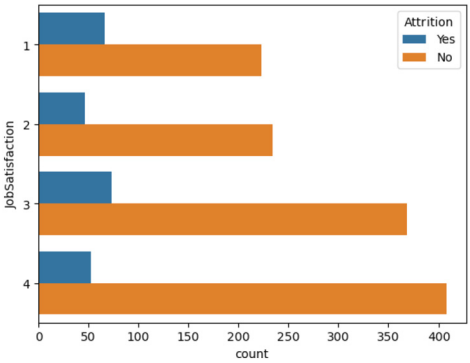

Fig. 5. Attrition visualization with a count plot based on job satisfaction

Finding and Observations

- The rate of attrition is significantly affected by job satisfaction.
- Employee attrition is low when employees are satisfied with their jobs.
- It has been shown that the lower job satisfaction results in higher attrition rates (Fig. 5).

3.3.6 Attrition Based on the Percent Salary Hike and Performance Rating

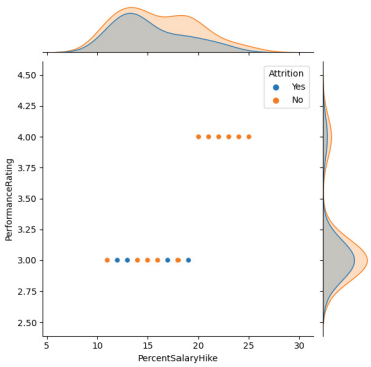

Fig. 6. Visualize the Percent Salary Hike and Performance Rating by attrition with joint plot

Finding and Observations

- It is observed that attrition rates within an organization can be affected by percent salary hikes and performance ratings.
- As positive performance ratings validate an employee's efforts and accomplishments; they drive to greater job satisfaction and lower attrition.
- Performance ratings are found to impact attrition rates more than percent salary increases (Fig. 6).

3.3.7 Attrition Based on Age

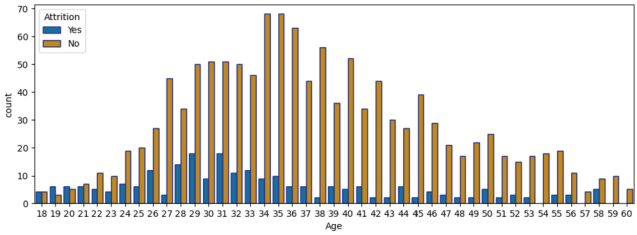

Fig. 7. Visualize the attrition rate by age with bar plot

Finding and Observations

- The age group of 29 and 31 represents the highest count of employee attrition.
- Among individuals, the highest retention rate is found between 34 and 35.

3.3.8 Visualization of Important Features

A visualization of the data would help to make sense of all the features (Fig. 7).

Finding and Observations

- Among the most important features appear to be a person's "monthly income", followed by their "age", "daily rate", and "monthly rate".
- Attrition rates are lower in individuals with higher income levels than in those with lower income levels, according to an observation.

3.4 Machine Learning Techniques

3.4.1 Investigating the Attrition Data with Machine Learning

After studying various algorithms from the literature, the following algorithms were used for developing a predictive model for churn, as these methods extended the enviable results. By dividing a dataset by a certain percentage, "% split" refers to the division of a dataset into different portions. This indicates how much of the dataset will be allocated to each portion. Split the dataset into training and test sets in 70:30 ratios.

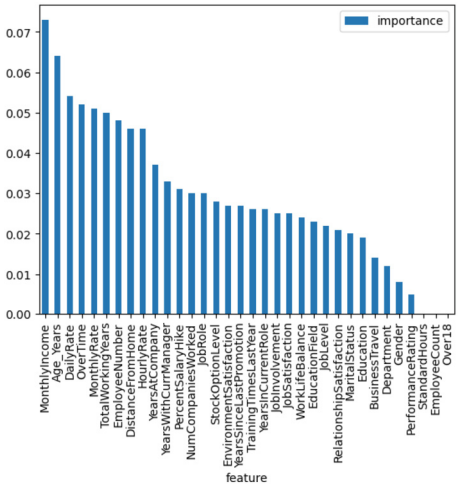

Fig. 8. A visualization of the important features

3.4.2 Building the Models

Supervised Classifiers

As part of the evaluation, different classification algorithms were used for evaluating the HR attrition dataset (Logistic Regression, K-Nearest Neighbours, Random Forest, Ada Boost and Gradient Boosting). The algorithm that produced the best results will be employed to create a classification model, and a percentage split option was used to test it.

Accuracy of Classification Models

A confusion matrix is used to estimate accuracy in classification problems. “Area Under the Receiver Operating Characteristic Curve (AUC)” is a more robust measure that takes into account the “true positive rate” (TPR) and “false positive rate” (FPR) of the classifier over a range of decision thresholds. Considering imbalanced datasets, AUC (Area Under the Curve) is considered a superior metric compared to accuracy, as it exhibits less sensitivity to the class distribution.

3.4.3 Logistic Regression

A logistic regression’s cost function is defined as either a log loss (log likelihood) or a binary cross entropy. Importing Logistic Regression is done using Sklearn. Linear models are fit with training data and are included in the linear model package. We now apply the model to the test set in order to make predictions. The predicted classes will be assigned to Pred_y. The class is not directly predicted, but probabilities are predicted and 0.5 is used as the cut-off point.

Confusion Matrix

Confusion matrices can be created using a dedicated function named "draw_cm()". With

this custom method, confusion matrices can be visualized based on actual and predicted class labels obtained from the models. This feature allows users to quickly draw and visualize confusion matrices for assessing a model's performance and accuracy (Fig. 9).

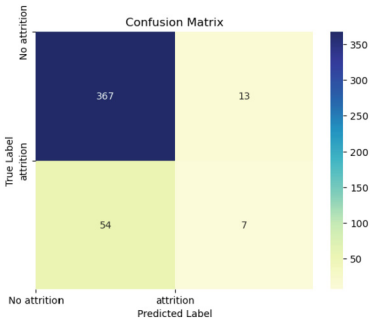

Fig. 9. Confusion metrics of Logistic Regression

Classification Report of Logistic Regression

In Skearn, a classification report can be run using the function classification report (). A comprehensive report of "precision", "recall", and "F1" scores is provided according to confusion metrics. An overview of the findings is depicted in Table 1.

Table 1. Logistic Regression Model Performance metrics

```
In [110]: from sklearn import metrics
          print(metrics.classification_report( test_y, pred_y ))
```

	precision	recall	f1-score	support
0	0.87	0.97	0.92	380
1	0.35	0.11	0.17	61
accuracy			0.85	441
macro avg	0.61	0.54	0.54	441
weighted avg	0.80	0.85	0.81	441

From Table 1, There is only a 0.11 recall for positive cases. In most cases, the outcome was predicted to be negative.

ROC Curve of Logistic Regression

ROC Curves can be visualized using the utility method draw_roc_curve(), which takes mode, test set, and actual test set labels. There are three parameters that are returned: the AC_score, false positive rate, and true positive rate, all of which range from 0.0 to 1.0. Figure 10 represents the plot of the ROC Curve. This corresponds to a 0.72 AUC value.

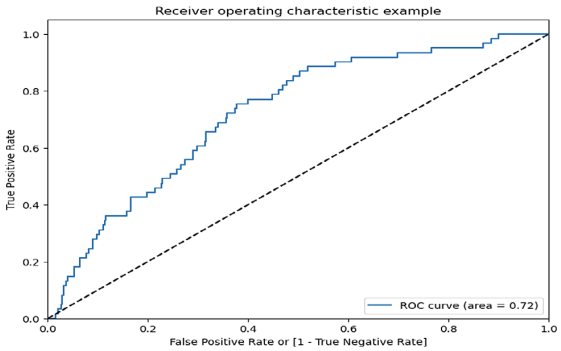

Fig. 10. ROC Curve of Logistic Regression

3.4.4 K Nearest Neighbour Classifier

An algorithm called K-NN can be used for regression and classification problems as it is a non-parametric, lazy learning algorithm. This algorithm finds observations that are similar to the new observation in the training set. The observations in this group are called neighbours.

In order to apply KNN algorithm to the HR attrition dataset the algorithms are run with the following default values.

i. "n_neighbours"="5"
ii. "metric"="minkowski"

ROC AUC Score is determined and the ROC curve is drawn. Based on Figure 12, the AUC Score of KNN is 0.55 (below the Logistic Regression) and the confusion matrix is generated.

Let the classification report for KNN model is generated and given in Table 2.

Recalls of positive cases have decreased to 0.03 as shown in Table 2. The above machine learning model is obtained by considering the default k=5. In KNN, K is called a hyperparameter, and tuning a hyperparameter means finding an optimal value (Fig. 11).

Confusion Matrix of KNN Classifier

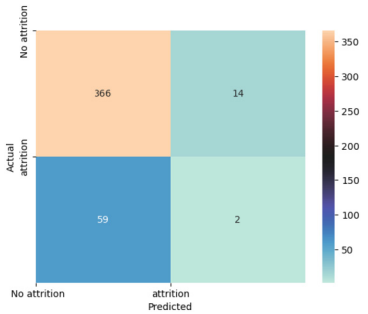

Fig. 11. KNN Classifier Confusion Matrix

Table 2. Classification report of KNN Classifier

Classification Report_K NN Classifier

```
In [130]: print( metrics.classification_report( test_y, pred_y ) )
```

	precision	recall	f1-score	support
0	0.86	0.96	0.91	380
1	0.12	0.03	0.05	61
accuracy			0.83	441
macro avg	0.49	0.50	0.48	441
weighted avg	0.76	0.83	0.79	441

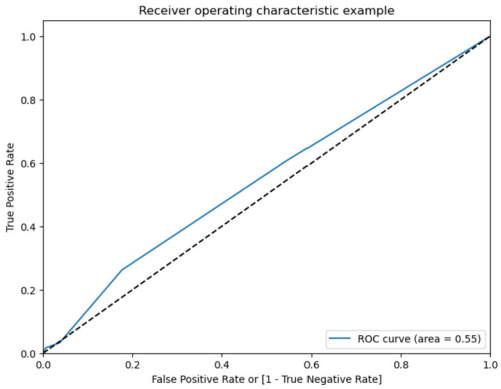

Fig. 12. ROC Curve of KNN Classifier

3.4.5 Random Forest (Ensemble Methods)

Procedure of Random Forest

- Model building with Random Forests.
- Models based on Random Forests are developed.
- A maximum depth of 10 is used in this scenario, while a number of estimators of 10 is employed.
- The ROC AUC Score is obtained by using the utility method draw_roc_curve ().
- The random forest model has the best AUC compared to the KNN model, at 0.71. The accuracy can still be improved by fine-tuning the hyperparameters in grid search.

Parameter optimization by grid search: The grid computing can be used to find the best hyperparameter values; however, grid search can take a long time. The parameters max_depth, n_estimators, and max_features will be tuned only, and a small set of values will be used. We can print the best score and best parameters.

AUC Score has reached 0.71 by Random Forest. Random forest model with 20 decision trees, automax number of features, and 15 maximal depth gives the best accuracy of 0.71 AUC Score.

Modelling with Optimal Parameter Values

The Random Forest model can perform better than Logistic Regression and KNN. The classification report is shown in Table 3. Using the Logistic regression and KNN model, we obtained 0.53 and 0.15 precision and recall for positive cases, respectively (Figs. 13 and 14)

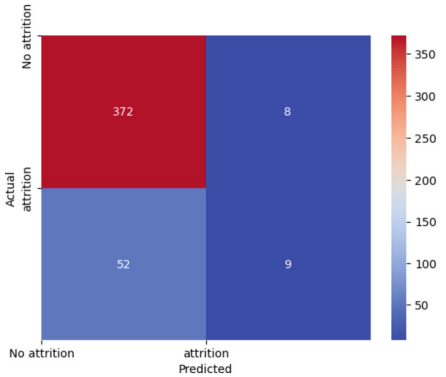

Fig. 13. Random Forest confusion matrix

Table 3. Random Forest classification report

Generation of Classification Report for Random Forest Classifier

```
In [85]: print( metrics.classification_report( test_y, pred_y ) )
```

	precision	recall	f1-score	support
0	0.88	0.98	0.93	380
1	0.53	0.15	0.23	61
accuracy			0.86	441
macro avg	0.70	0.56	0.58	441
weighted avg	0.83	0.86	0.83	441

The Use of Random Forests to Identify Important Features

By considering feature usage over all trees in the forest, random forest reports feature importance. In terms of the outcome variable, this provides good insight into which features are important. It used "Gini impurity reduction" or "mean decrease impurity" for calculating the feature importance. Classifiers in Sklearn return a parameter called feature importance, which holds feature importance values.

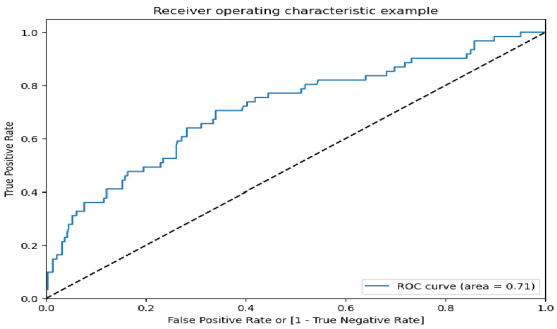

Fig. 14. ROC Curve of Random Forest

The top 5 features are "Monthly income", "age", "Total working years", "Daily rate and over time". Table 4 shows how to compute the cumulative sum using the pandos cumsum() method.

Table 4. Feature Importance by Random Forest

feature	importance
MonthlyIncome	0.070
Age_Years	0.060
TotalWorkingYears	0.059
DailyRate	0.055
OverTime	0.052
EmployeeNumber	0.051
MonthlyRate	0.049
DistanceFromHome	0.048
HourlyRate	0.046
YearsAtCompany	0.036
PercentSalaryHike	0.033
NumCompaniesWorked	0.032
EnvironmentSatisfaction	0.029
JobRole	0.029
YearsWithCurrManager	0.028
StockOptionLevel	0.028
YearsInCurrentRole	0.027
JobInvolvement	0.026
JobSatisfaction	0.026
TrainingTimesLastYear	0.026
WorkLifeBalance	0.024
YearsSinceLastPromotion	0.024
RelationshipSatisfaction	0.023

3.4.6 Adaboost

A data set of records is weighed by Adaboost, which determines whether a particular record is selected for classifier training.

A model of the Adaboost classifier is built based on the following parameters.

i. Base Estimators
ii. n Estimators
iii. Learning Rate

ROC Curves are drawn for the AdaBoost classifier using the custom method draw_roc_curve () (Fig. 15).

Figure 16 illustrates, the AUC for the Adaboost is 0.77 (Table 5).

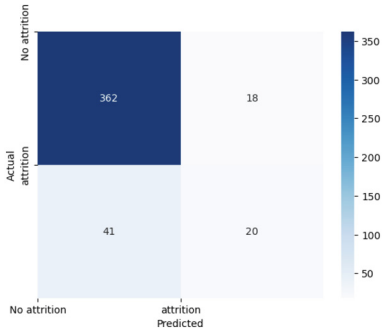

Fig. 15. Confusion matrix of Ada boost

Table 5. Classification report of Adaboost

```
In [106]: print( metrics.classification_report( test_y, pred_y ) )
```

	precision	recall	f1-score	support
0	0.90	0.95	0.92	380
1	0.53	0.33	0.40	61
accuracy			0.87	441
macro avg	0.71	0.64	0.66	441
weighted avg	0.85	0.87	0.85	441

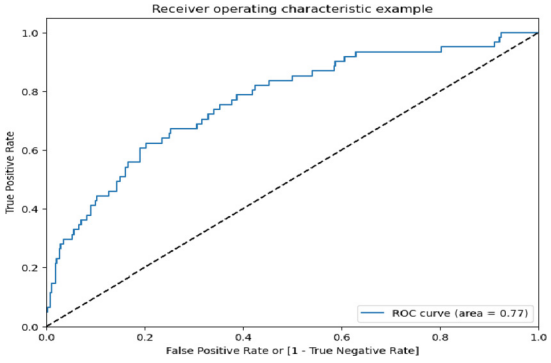

Fig. 16. ROC Curve of Adaboost

3.4.7 Gradient Boosting

When gradient boosting is performed, the following steps are taken:

i. Analyze the data using the first model.
ii. Based on the residuals, fit the next model
iii. Until there is no significant change in the residuals, repeat the above steps.
iv. In order to make the final predictions, the final model is used.

The following key parameters are taken into account by the gradient boosting classifier.

i. n_estimators
ii. max_depth
iii. max_features

A model with 500 estimators and a max_depth of 100 is built.

In Figure 18, the ROC curve for gradient boosting is shown. AUC is 0.70 for the corresponding model. A recall of 39% was achieved by the model (Fig. 17 and Tables 6, 7).

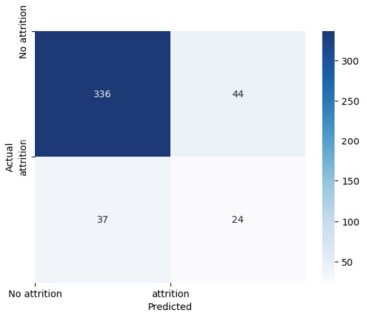

Fig. 17. Confusion matrix of Gradient boosting

Table 6. Gradient boosting Classification report

Classification Report_Gradient Boosting

```
In [98]: print( metrics.classification_report( test_y, pred_y ) )
```

	precision	recall	f1-score	support
0	0.90	0.88	0.89	380
1	0.35	0.39	0.37	61
accuracy			0.82	441
macro avg	0.63	0.64	0.63	441
weighted avg	0.83	0.82	0.82	441

Figure 18 shows the ROC curve for gradient boosting. As a result, the AUC is 0.70.

AUC score for the model is 70%. Based on TPR, it seems to be the best model of all the ones we have built so far. The model will recall reaching 0.39.

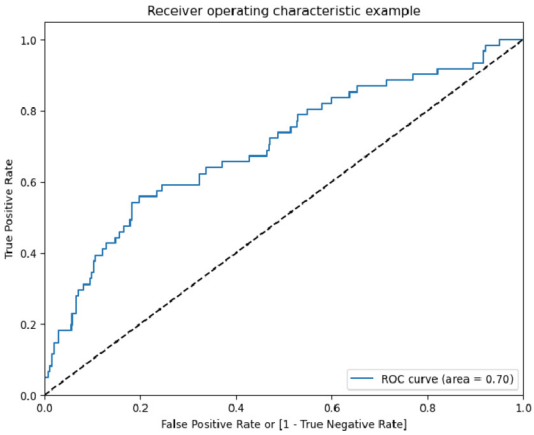

Fig. 18. ROC of Gradient Boosting

Table 7. AUC Score and TPR of various classifiers

Classifier	TPR	AUC Score
Gradient Boosting	0.39	0.70
Random Forest	0.15	0.71
KNN	0.03	0.55
Ada Boost	0.33	0.77
Logistic Regression	0.11	0.72

4 Conclusion

Attrition occurs as employees retire or resign without being replaced, resulting in a gradual reduction in staff numbers. Businesses can incur significant costs as a result of employee attrition. As a result of attrition, the organization fails to keep the effectivity and wisdom of employee.

Human resources professionals often use the terms turnover and attrition interchangeably, even though they are distinct terms. Attrition and turnover are both caused by employees leaving a company. The turnover process, however, can be triggered by various actions, such as “discharge”, “termination”, “resignation”, or “abandonment”. Retirement or elimination of a position results in employee attrition, and employees leave their jobs as a result. When turnover occurs, an employee is replaced by the company. However, attrition means that the employer leaves the position unfilled or eliminates it

The main objective of the proposed work is to address the possible solutions for the below listed questions on employee churn:

1. How can employee churn be reduced?
2. What causes remarkable employees to leave an organization?
3. Who are the most likely to leave the company?

Kaggle data is used to predict whether the employee will remain or leave the organization. Python is used in this work as a high-level language with an interpreter and a large standard library. For the intention of predicting the staffer accuracy, machine learning techniques were used to analyse the data.

Each instance in a dataset is described by attribute values based on classification algorithms like Logistic Regression, K-NN, Random Forest, Adaboost and gradient boosting which will provide the most accurate accuracy measures. The purpose of this work is to discover how machine learning can be used to analyse and predict worker attritions using existing datasets, so as to develop effective decision-making knowledge, and to develop a better machine learning model of using a classification algorithm.

The Following ML Techniques are Applied

- Data Pre-Processing
- Exploratory Data Analysis
- Machine Learning
- Among the algorithms tested on the employee attrition dataset, Gradient Boosting and Ada Boost have the highest accuracy.
- In terms of TPR and AUC Score, the Gradient Boosting Classifier outperforms other existing classifiers.
- Data analysis, visualization, and analytical model building were used in this project to predict employee attrition. With the goal of predict in case an employee will stay or move on, classification models were developed.
- In summary, Exploratory Data Analysis, Machine Learning approaches can assist in predicting employee attrition.

4.1 Summary and Recommendation

- Considering IBM's 16.12% employee attrition rate, a reduction would result in more cost savings.
- The highest rate of attrition was found in Sales Department, but not much higher than HR, but it was lowest in R&D.
- Males had a higher attrition rate of 17.01 % compared to females who had a rate of 14.80%.
- People doing over time had a very high reaching rate of attrition of 30.53%.
- Majority of hired hand who leave the company within the first three years of their employment.
- Approximately 15% of employees complete 10 or more years with the organization.
- Many employees earn less than a few employees and the monthly income is not distributed normally.
- Based on the Chi Square Independent Test, it has been statistically proven that attrition and Job Satisfaction, Attrition and Overtime are significantly related.
- The gender bias in IBM has also been statistically proven to be non-existent, and attrition has no relation to gender.
- In the end, the models are built to predict whether an employee will stay or leave the organization.

- Human resources managers should investigate the causality of attrition in the Sales Department, as overtime is not the only reason for resignations.
- In light of the fact that overtime is associated with attrition, some policy changes with respect to overtime should be made. It would be best to limit overtime or to increase overtime allowances.
- When someone leaves in their early years, employee engagement should be a priority, and proper onboarding should be carried out to prevent culture shock.
- Historically, stock options were not considered to be an important factor when predicting the number of years an employee would remain with the organization.
- It is rare for employees to work for an organization for more than 10 years. The ability of an employee to remain for a longer period of time can be increased through succession planning and clear communications.

It has been determined that the top reasons why employees leave an organization are no overtime, monthly income, and age. Employees who are not paid for the overtime work they perform are more likely to leave the organization, as expected income is a big factor. In most cases, employees leave their jobs to seek a better salary. People who are retiring have to leave their jobs due to age factors. As a result of knowing the significant cause why worker left an organization. It will enable the organization to take the necessary steps to reduce the level of attrition.

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Continuance Intention of ChatGPT Use by Students

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Abstract. ChatGPT, an AI language model, has gained significant attention for its potential to enhance educational experiences and foster interactive learning environments. The potential of student interaction via ChatGPT has engendered significant debate around educational technology. It is apparent that the current literature has yet to fully explore the role of ChatGPT in management education. Amidst the increasing integration of ChatGPT into educational contexts, the concept of continuance intention takes center stage. This research paper delves into the nuanced landscape of students' continuance intention regarding the use of ChatGPT in educational settings. We ground our study in Technology Continuance Theory and Theory of Planned Behavior to examine students' continuance intention to use ChatGPT. By investigating the determinants that shape this intention, we aim to provide insights that inform educators and educational technology designers in optimizing the integration of AI-driven tools like ChatGPT. This study contributes to the growing body of research at the intersection of AI and education, offering valuable implications for both theory and practice.

Keywords: ChatGPT · Education · Technology Continuance Theory · Theory of Planned Behavior · Continuance Intention

1 Introduction

In the rapidly evolving landscape of education, technology has emerged as a transformative force, reshaping traditional teaching, and learning methodologies. One of the most remarkable advancements in this arena is the development and integration of Artificial Intelligence (AI) technologies [2]. The advancements and growth observed in the field of machine learning have resulted in the development of increasingly advanced and novel technologies, such as generative artificial intelligence, which enables the generation of digital content [3]. Generative modelling in the field of artificial intelligence (AI) refers to a machine learning framework that operates in an unsupervised or partially supervised manner [4]. The existing body of literature has recognized two primary forms of generative artificial intelligence: the Generative Adversarial Network (GAN) and the Generative Pre-trained Transformer (GPT) [3–5]. Generative Pre-trained Transformer

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(GPT) models leverage extensive collections of publicly accessible digital content data, specifically in the domain of natural language processing (NLP). These models demonstrate a remarkable capacity for creative writing, capable of producing coherent and persuasive textual compositions ranging from individual paragraphs to comprehensive research articles. This versatility extends to encompassing a wide array of subject matters, enabling the models to convincingly emulate human-like writing with a high degree of fidelity.

ChatGPT and Bard are two examples of modern generative AI software, with ChatGPT receiving the most attention in terms of cutting-edge developments. Within two months of its inception, ChatGPT, had attracted 100 million users [6]. ChatGPT has received a lot of interest because of its promising ability to improve classroom instruction and encourage collaborative learning [7]. As the adoption of ChatGPT in educational settings grows, understanding students' intentions to continue using this technology becomes crucial to harness its benefits effectively. According to the latest data as of June 2023, a survey revealed that approximately 10.8 percent of global corporate personnel have experimented with the implementation of ChatGPT inside their professional environments on at least one occasion [8].

ChatGPT, developed by OpenAI, is a contemporary language model that exhibits remarkable proficiency in understanding and generating human-like text [9]. Its applications span various domains, including customer service, content creation, and even educational assistance. By simulating natural language conversations, ChatGPT offers students the opportunity to engage in dynamic interactions that extend beyond conventional classroom boundaries. This AI-powered tool holds the promise of personalized learning experiences, instant academic support, and novel ways of exploring complex subjects[2, 10]. The possibility for student interaction through ChatGPT has sparked intense discussion about educational technology and its role in society [11]. It is clear that the relevance of ChatGPT in management education has not yet been thoroughly explored in the existing literature [1]. The purpose of this paper is, therefore, to provide a link between the literatures of artificial intelligence and management education. Amidst the increasing integration of ChatGPT into educational contexts, the concept of continuance intention takes center stage. Continuance intention refers to an individual's inclination to persist in using a particular technology over time [12]. In the case of ChatGPT, understanding the factors that influence students' intention to continue using the technology is paramount for educators, researchers, and developers alike. Exploring these factors can shed light on the aspects that contribute to the adoption and sustained utilization of ChatGPT, leading to its effective incorporation into pedagogical practices. Further, Chat GPT possesses the potential to be a valuable instrument for open education due to its capacity to enhance the self-reliance and self-governance of autodidactic learners, while also exhibiting practicality and adaptability [13].This research paper delves into the nuanced landscape of students' continuance intention regarding the use of ChatGPT in educational settings. By investigating the determinants that shape this intention, we aim to provide insights that inform educators and educational technology designers in optimizing the integration of AI-driven tools like ChatGPT. This study contributes to the growing body of research at the intersection of AI and education, offering valuable implications for both theory and practice.

The contributions of the study are manyfold. The paper integrates the Technology Continuance Theory (TCT) and Theory of Planned Theory of planned behavior (TPB) to provide a holistic explanation for students' continuance intention to use ChatGPT. The study contributes to the literature on the continuance intention to use ChatGPT by students by exploring the determinants of continuance intention to use. The present research illustrates the applicability of the TCT and TPB in the context of students' continuance intent to use ChatGPT. The integration of TCT and TPB provides a more comprehensive understanding of the factors influencing students' continuance intention. While TCT explores factors such as perceived usefulness, ease of use, and satisfaction, TPB considers attitudes, subjective norms, and perceived behavioral control. This layered analysis provides a richer insight into students' decision-making process. TCT emphasizes cognitive factors related to technology adoption and usage, while TPB highlights the role of social influences and subjective perceptions. The integration of these theories helps in balancing the cognitive and social aspects, acknowledging that both play a role in shaping students' continuance intentions.

The paper proceeds as follows: the next section introduces the background on ChatGPT. Subsequently the paper discusses theory and hypotheses development followed by research method and results and analysis of the hypotheses testing. The final section discusses the study's findings, contributions, and implications.

2 Background

Research on the application of ChatGPT in the field of management is an emerging area. In a recent review [2], the education industry has been identified as one of the sectors that has seen significant disruptive effects due to the implementation of ChatGPT. The writers also take into account the constraints of the subject matter, potential disruptions to established practices, concerns regarding privacy and security, as well as the potential implications stemming from biases, misuse, and the spread of disinformation. However, there is a divergence of opinions regarding whether the utilization of ChatGPT should be subject to limitations or regulatory measures. The paper identifies many avenues for future research in generative AI technology. Further, ChatGPT possesses a distinctive quality that sets it apart from other educational technologies: its exceptional capabilities render it highly elusive and difficult to detect throughout usage [7]. This situation presents a predicament for management educators who seek to use technology in their teaching practices while simultaneously maintaining relevance and fostering real learning experiences. Therefore, it is imperative for educators in management to expeditiously enact regulations pertaining to ChatGPT and later iterations of generative artificial intelligence due to its user-friendly nature and cost-effectiveness. There is a pressing necessity to critically reassess current educational methodologies with the aim of integrating novel technological advancements that can be effectively used for advantageous purposes. In another study [14], the authors aimed to identify the quality of short answer outputs for sport management questions from ChatGPT and made recommendations on how to use ChatGPT in the functional areas of sport management. Another study [15] focused on important AI-related issues faced by the university including new opportunities to develop new ways to improve capacities within classrooms. While ChatGPT offers numerous opportunities, it is not without challenges. The issue of plagiarism

is becoming increasingly prominent within the realm of education due to the escalating number of students who are relying on ChatGPT for conducting research and accessing information. The utilization of ChatGPT by students has the potential to facilitate academic dishonesty, as it enables them to exploit the chatbot by providing it with tailored prompts and inquiries, thereafter copying and incorporating the generated responses verbatim into their own written work [16, 17].

In summary, the existing body of literature pertaining to the utilization of ChatGPT by students in the context of management education is currently in its nascent stages of development. While ChatGPT can be a valuable tool for supporting student learning in management education, it also raises some ethical concerns. There is a concern that ChatGPT could be used for cheating and plagiarism. There is also the concern that ChatGPT could be used to manipulate students or to spread misinformation. These ethical concerns need to be carefully considered before ChatGPT is adopted in management education. It is important to be aware of the ethical concerns associated with using ChatGPT and to take steps to mitigate these concerns. As the technology continues to develop, it is likely that ChatGPT will become even more widely used in management education. It has the potential to be a powerful tool for supporting student learning and for preparing students for the challenges of the 21st century workplace.

3 Theory and Hypothesis Development

3.1 Technology Continuance Theory (TCT)

The TCT is initially established by Liao et al. (2009) as an enhanced framework to investigate IS continuance use. TCT is a theoretical framework that focuses on understanding why individuals continue to use or adopt technology over time. It aims to explain the factors that influence a person's decision to persist in using a particular technology, even after the initial adoption phase. TCT builds upon earlier theories such as the Technology Acceptance Model (TAM), Expectation Confirmation Model (ECM). While TAM primarily focuses on explaining initial technology adoption based on perceived ease of use and perceived usefulness, TCT goes a step further by examining the factors that influence individuals' intentions to continue using a technology after the initial adoption period. TCT provides a comprehensive perspective on the factors that influence users' decisions to persist with a technology. The TCT underpins six constructs including satisfaction, confirmation, perceived usefulness, attitude, perceived ease of use and user continuance intention. The key contribution of TCT is that it combines attitude and satisfaction in one technology continuous model (Liao et al., 2009). The TCT confirms that it has more applicability and explanatory power when comparing with ECM, TAM. Moreover, the TCT indicates that the success of technology is dependent on long-term use instead of initial acceptance (Pattanayak et al., 2017).

TCT incorporates five factors, including confirmation, perceived use (PU), perceived ease of use (PEU), attitude, and satisfaction, to describe the likelihood that users may continue to use a technology. TCT provides a valuable contribution to the debate regarding continued usage by integrating attitude and satisfaction into a single model that demonstrated a high power in explaining Theory of planned behavior (TPB)s in the

post-adoption stage [18]. User PU, attitude, and satisfaction determine continued intentions. Confirmation and PU form satisfaction level of users. Satisfaction, PEU, and PU all contribute to user attitudes. PEU and confirmation shape PU. Various studies have applied TCT in explaining user Theory of planned behavior (TPB) towards continuance intention to use technologies [18–21]. In this study, we employ the TCT model to explain students' continued usage of ChatGPT. Studying students' continued use of ChatGPT is essential for several reasons, as it contributes to a deeper understanding of the dynamics, implications, and potential benefits of integrating AI-powered tools into education. Analyzing the patterns of continued use can lead to pedagogical innovation and novel approaches to teaching and learning. Educators can explore creative ways to integrate ChatGPT into lesson plans, assignments, and discussions to foster deeper engagement and critical thinking among students. Further, it contributes to improved understanding, knowledge retention, and academic performance. This knowledge can inform educators on how to effectively integrate AI-driven tools to support and enhance traditional teaching methods.

Although TCT provides a solid foundation for exploring the continuance intention, it is suggested that the combination and/or extension of different theories enable researchers to get a better understanding of constructs related to pre-/or post-adoption behaviors [20, 22–24]. Accordingly, to better understand the student's usage Theory of planned behavior (TPB) of ChatGPT, we combine Theory of Planned Behavior with TCT to better understand students' continued intention to use ChatGPT.

3.2 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) [25] is a theory that provides insights into the factors that influence human behavior. It was proposed as an extension of the earlier Theory of Reasoned Action. TPB aims to explain and predict the intention to engage in a specific behavior and the subsequent behavior itself. The theory posits that human behavior is primarily determined by an individual's intentions, which in turn are influenced by three main factors: attitudes, subjective norms, and perceived behavioral control. Attitudes refer to an individual's personal evaluation of a particular behavior. It involves assessing whether the person views the behavior positively or negatively. Attitudes are formed based on an individual's beliefs about the potential outcomes and consequences of the behavior. Positive attitudes toward a behavior are more likely to result in the intention to perform that behavior. Subjective norms refer to the perceived social pressure or influence that others have on an individual's behavior. This includes the perceived expectations and opinions of significant others, such as family, friends, and colleagues. Perceived behavioral control (PCB) refers to an individual's perception of their ability to perform the behavior. It considers the perceived ease or difficulty of engaging in the behavior, as well as the presence of external factors that might facilitate or hinder the behavior. High perceived behavioral control can lead to a stronger intention to engage in the behavior, while low perceived control can weaken the intention [12, 26]. The intention to perform a behavior is a central component of the theory. This intention is influenced by the interplay of attitudes, subjective norms, and perceived behavioral control. In turn, this intention strongly predicts whether an individual will actually engage

in the behavior. The TPB has been widely to understand Theory of planned behavior (TPB) [12, 22, 27–29].

In this study we posit that subjective norm, PCB, and attitude influence students' continued intention to use ChatGPT. Together TCT and TPB can provide a comprehensive framework for explaining and understanding students' intention to continue using ChatGPT. Both theories offer unique insights into different aspects of user behavior, and their integration can enhance the explanatory power of the model. TCT focuses on factors that influence users' intention to continue using a technology, emphasizing the role of perceived usefulness and satisfaction. On the other hand, TPB examines the influence of attitudes, subjective norms, and perceived behavioral control on behavioral intentions. By combining both theories, you encompass cognitive and social factors that impact students' decisions to continue using ChatGPT. In summary, combining the Technology Continuance Theory and the Theory of Planned Behavior offers a more comprehensive and nuanced perspective on students' intention to continue using ChatGPT. This integration enables researchers to capture cognitive, affective, social, and contextual factors that collectively shape user behavior, yielding a more robust explanation and actionable insights for improving the tool's effectiveness and usage.

3.3 Hypotheses

The degree to which one's actual experience confirms their initial expectation is known as confirmation (Bhattacherjee, 2001). Based on ECM, if the initial expectation of ChatGPT is confirmed or even exceeded, it consequently influences students' satisfaction, whereas students will be dissatisfied if their expectations are not met. Prior research stated that confirmation is a driver of satisfaction (Foroughi et al., 2019). If student's initial expectations of ChatGPT is met, they will be satisfied with ChatGPT. Furthermore, extant research has demonstrated a positive association between confirmation and PU (Huang et al., 2019; Khayer & Bao, 2019). At the post-adoption stage, individuals tend to modify their perception regarding the advantages of a technology based on their initial experience. It means that if the benefits or actual performance of using ChatGPT outperforms student's expectations, it most probably increases the student's perception of usefulness towards the tool. Therefore, we posit:

H1: Confirmation will positively influence students' satisfaction with the use of ChatGPT
H2: Confirmation will positively influence students' perceived use of ChatGPT.

Perceived usefulness (PU) refers to individual beliefs regarding a new technology's ability to enhance performance [30]. Prior research has determined that PU is a determinant of positive attitude, satisfaction, and continuance intention in information technology studies [31]. PU has been found as a critical factor in explaining an individual's behavioral intention[18, 20]. Thus, we posit that if students find ChatGPT useful, they will be satisfied, have a positive attitude toward the app, and, therefore, be more prone to continue using it. Consequently, the following hypotheses were postulated:

H3: PU positively influences students' satisfaction with the use of ChatGPT
H4: PU positively influences students' attitude to use ChatGPT
H5: PU positively influences students' continuance intention to use ChatGPT

Perceived ease of use (PEU) represents the degree to which the use of a system would be free of mental and physical efforts (Davis, 1989). PEU indicates the effort required to learn and use technology. Prior research on new technology indicated that PEU positively influences attitude [31, 32]. In the ChatGPT context, it is assumed that if students could learn, understand, and use ChatGPT without much endeavor, they are more likely they believe that using ChatGPT delivers better performance and consequently leads to a positive attitude towards using it. Thus, we posit:

H6: PEU positively influences student's attitudes towards using ChatGPT
H7: PEU positively influences students' PU to use ChatGPT

Satisfaction refers to the perceived difference between expectation and performance after consumption [33]. As per the Expectation-Confirmation Model, satisfaction is a significant predictor of post-adoption behaviors [22, 33]. Prior research has supported the positive effect of satisfaction on attitudes and continuance intention [19, 34]. Hence, in the ChatGPT context, if students are satisfied with the services provided by ChatGPT, it will increase their positive attitude and will reinforce students' continued intention towards using ChatGPT. Thus, the study posits:

H8: Satisfaction positively influences student's attitude towards using ChatGPT
H9: Satisfaction positively influences continuous intention to use ChatGPT by students

TPB postulates that a particular behavior is determined by the intention to perform the behavior, which is predicted by three factors: attitude toward the behavior, subjective norms, and perceived behavioral control. Attitude refers to 'the degree of a person's positive or negative feelings about performing a target behavior' [30]. Attitude is considered a key determinant of behavioral intention in various technology post-adoption theories [18]. Several studies have supported the positive association between individuals' attitudes and continuance usage intention [19, 20, 22, 27, 34–36]. Thus, following the above argument, it is expectable that student's intention to continue using ChatGPT is positively and directly influenced by their attitudes towards it. Subjective norm refers to an individual's perception of social references, or relevant others' beliefs that he or she should or should not perform such behavior. Because people always turn to groups for their standards of judgment, any person(s) served as a reference group could have a key influence on individuals' beliefs, attitudes, and choices. Perceived behavioral control is about an individual's perceptions of his or her ability to perform a given behavior [37]. Therefore, we posit the hypotheses related to subjective norms towards use of ChatGPT by students, attitude towards use of ChatGPT by students, and perceived behavioral control of students' use of ChatGPT as:

H10: Students' subjective norms toward use of ChatGPT will positively influence their continuance intention to use ChatGPT
H11: Students' attitude toward use of ChatGPT by will positively influence their continuance intention to use ChatGPT
H12: Students perceived behavioral control of use ChatGPT will positively influence their continuance intention to use ChatGPT (Fig. 1)

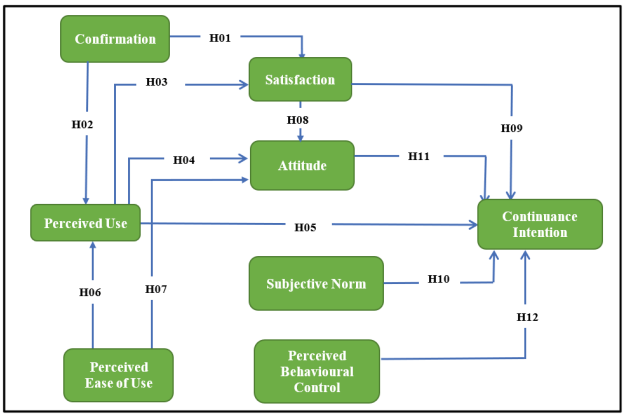

Fig. 1. Proposed research model

4 Research Method

The present study designed a survey instrument in which all items were adapted from prior research. The items of PEU and PU were adapted from Davis [30] and Venkatesh & Davis [38], respectively. The items of confirmation and satisfaction were adapted from Bhattacherjee [33]. TPB constructs were adapted from Pavlou & Fygenson [12]. A seven-point Likert scale anchored by 'strongly disagree (= 1)' to 'strongly agree (= 7)' was used to measure the items due to their wide application in quantifying the constructs of the study and the ease with which the respondents can understand and make judgments about the items.

The surveys were conducted in classes with a convenient sample of undergraduate and postgraduate management students in Delhi NCR region, India. The subjects were asked to answer a questionnaire. A total of 120 questionnaires were submitted. The respondents consisted of 67.5% males and 32.5% females. 86.7% of respondents were aged below 26 years (Gen Z) and 13.3% were aged between 27–42 years (millennials). More than 50% of the respondents had completed high school and were pursuing under graduation while 30% had completed under graduation and were pursuing post-graduation and 15% of respondents had completed post-graduation also.

Since data were obtained from a single source, the current research evaluated common method variance (CMV). We examined the collinearity test suggested by Kock [39] to assess the CMV. The results specify that the variance inflation factor (VIF) for all variables was below the suggested value of 3.3 specifying that CMV was not a serious issue. Then, we further conducted Harman's single-factor test by loading all the question items into an exploratory factor analysis (EFA) [40]. The findings of this test revealed that the first factor accounted for less than 50% of the total variance and no dominant factor was found in factor analysis. Thus, common-method variance is not a problem in our survey.

The data analysis was carried out using structural equation modelling (SEM) in line with previous studies. The research model was tested with measurement model and structural model. The measurement model assessed the reliability and validity of the instrument and then we analyzed the structural model for hypotheses testing. Two control variables namely age of students and gender of students were employed in the model. These variables have been taken from prior literature on TCT age and gender were commonly used as controls for continuance intention.

5 Results and Analysis

We used Structural Equation Modelling (SEM) to test the proposed hypotheses. The study conducted an exploratory factor analysis (EFA) to check the latent variable of the proposed model. To ensure the reliability of indicators, we removed items with loading less than 0.70. This led to reduction of 30 items to 24 items. After this, confirmatory factor analysis (CFA) was conducted to measure the effectiveness of the measurement. To examine the reliability and validity of the scales, Cronbach's α, convergent validity and discriminant validity were employed. Table 1 shows Cronbach's α, factor loadings, composite reliability (CR) and average variance extracted (AVE) and Table 2 shows discriminant validity. The result of the study shows that the value of Cronbach's α and CR is above 0.7 which is a good indicator of reliability [41, 42]. Also, the value of AVE is more than 0.5 which is an indicator of good convergent validity [43]. Discriminant validity was utilized to assess how different the constructs and components were from each other. The model fulfilled the criteria for discriminant validity because "the square root of AVE was greater than the correlation value among the reflective constructs" [42]. The CFA findings demonstrate an excellent fit" "$\chi 2 = 379.571$, $\chi 2/df = 1.71$, CFI = 0.951, RMSEA = 0.078, SRMR = 0.042" [44]. Hypothesis testing was done through structural model. The results of SEM shows an acceptable fit: "$\chi 2 = 402.239$, $\chi 2/df = 1.734$, CFI = 0.947, RMSEA = 0.079″ [44] (Table 3).

Table 1. Cronbach's α, Factor loadings, composite reliability (CR) and AVE

S. No	Constructs	Variable	λ	Cronbach's Alpha	CR	AVE
1	Perceived Usefulness	PU1	0.842	0.944	0.946	0.513
		PU2	0.969			
		PU3	0.959			
2	Perceived Ease of Use	PEOU1	0.74	0.845	0.795	0.564
		PEOU2	0.726			
		PEOU3	0.787			
3	Satisfaction	SAT1	0.788	0.938	0.846	0.648
		SAT2	0.807			
		SAT3	0.82			
4	Confirmation	CON1	0.809	0.929	0.837	0.631
		CON2	0.771			
		CON3	0.804			
5	Attitude	ATT1	0.899	0.920	0.938	0.501
		ATT2	0.857			
		ATT3	0.982			
6	Continuation Intention	CI1	0.814	0.937	0.862	0.507
		CI2	0.795			
		CI3	0.857			
7	Subjective Norm	SN1	0.791	0.907	0.824	0.626
		SN2	0.799			
		SN3	0.784			
8	Perceived Behavioral Control	PBC1	0.987	0.970	0.947	0.514
		PBC2	0.893			
		PBC3	0.895			

Table 2. Discriminant Analysis

	PU	PEOU	SAT	CON	ATT	CI	SN	PBC
PU	**0.716**							
PEOU	.570**	**0.75**						
SAT	.538**	.706**	**0.805**					
CON	.566**	.674**	.767**	**0.798**				
ATT	.637**	.648**	.697**	.684**	**0.707**			
CI	.639**	.569**	.614**	.644**	.659**	**0.712**		
SN	.526**	.576**	.570**	.549**	.627**	.653**	**0.791**	
PBC	.613**	.664**	.672**	.722**	.705**	.658**	.610**	**0.717**

Note: Significance at: ** p < .01

Table 3. Hypothesis Testing

Hypotheses	Estimate	S.E.	C.R.	P	Result
Confirmation→Perceived usefulness	.458	.079	5.815	***	Yes
Perceived ease of use→Perceived usefulness	.346	.094	3.694	***	Yes
Confirmation→Satisfaction	.357	.075	4.780	***	Yes
Perceived usefulness→satisfaction	.187	.081	2.312	**	Yes
Perceived usefulness→Attitude	.419	.104	4.017	***	Yes
Perceived ease of use→Attitude	.119	.092	1.301	Not Significant	No
Satisfaction→Attitude	.509	.122	4.163	***	Yes
Satisfaction→Continuance intention	.234	.104	2.252	**	Yes
Attitude→Continuance intention	.380	.092	4.122	***	Yes
Subjective norm→Continuance intention	.214	.056	3.806	***	Yes
Perceived behavioral control→Continuance intention	.166	.065	2.553	**	Yes
Perceived use→Continuance intention	.169	.086	1.969	.049	Yes

6 Discussion

It is theoretically motivating and empirically appealing to uncover the mechanisms through which students intend to continue to use ChatGPT. The purpose of the study was to understand students' continuance intention of ChatGPT tool. We ground the present study in Technology Continuance Theory and Theory of Planned Behavior to obtain a holistic understanding of students' continuance intention to use ChatGPT. Combining Technology Continuance Theory (TCT) with the Theory of Planned Behavior (TPB) can provide a comprehensive framework for understanding students' continuance intention to use ChatGPT. This integrated approach considers both the cognitive and social factors that influence users' decisions to continue using a technology. As a result of this integrated approach, we developed hypotheses to test students' continuance intention to use ChatGPT.

We had hypothesized that confirmation will positively influence students' continuance intention of ChatGPT(H1) as well as perceived usefulness of ChatGPT (H2). According to results we found a positive and significant relationship between confirmation and perceived usefulness lending supporting to H1 and H2. We had further hypothesized that perceived usefulness will be positively associated with satisfaction (H3), attitude (H4), and continuance intention (H5). We found a positive and significant relationship between perceived usefulness and satisfaction as well as between perceived usefulness and attitude lending support to H3 and H4. We also found a positive and significant relationship between perceived usefulness and continuance intention lending support to H5. According to our theoretical grounding we had posited that perceived ease of use will positively influence attitude (H6) and perceived usefulness (H7). As per our results, we found a positive and significant relationship for H6 but not for H7. This was a surprising but an interesting finding not unseen in prior literature [19, 45]. This maybe because students may use ChatGPT not just for educational purposes but for non-educational purposes as well as a result of which they may focus on overall benefits of ChatGPT and consequently their attitudes may not be shaped by PEU. Moreover, with time students may get used to ChatGPT and more skilled at its use through frequent usage. Therefore, their PEU may not necessarily shape their attitude. In addition, we had also posited that satisfaction will be positively associated with attitude (H8) and continuance intention (H9) of students to use ChatGPT. We found a positive and significant relationship for both H8 and H9. As per our theoretical grounding in TPB, we had further hypothesized that subjective norm (H10), attitude (H11) and perceived behavioral control (H12) will be positively associated with students' continuance intention to use ChatGPT respectively. We positive and significant relationships for these relationships as well. In sum we found support for almost all the hypotheses.

6.1 Theoretical Implications

The study offers several significant theoretical implications. The study contributes to the literature on the continuance intention to use ChatGPT by students by exploring the determinants of continuance intention to use. The present research illustrates the applicability of the TCT and TPB in the context of students' continuance intent to use

ChatGPT. The integration of TCT and TPB provides a more comprehensive understanding of the factors influencing students' continuance intention. TCT focuses on factors related to the technology itself, while TPB considers both individual beliefs and social influences. This comprehensive perspective helps in identifying a wider range of factors affecting behavior. While TCT explores factors such as perceived usefulness, ease of use, and satisfaction, while TPB considers attitudes, subjective norms, and perceived behavioral control. This layered analysis provides a richer insight into students' decision-making process. TCT emphasizes cognitive factors related to technology adoption and usage, while TPB highlights the role of social influences and subjective perceptions. The integration of these theories helps in balancing the cognitive and social aspects, acknowledging that both play a role in shaping students' intentions. The integrated model facilitates the design of more holistic interventions. By addressing factors from both TCT and TPB, interventions can be tailored to enhance students' perceived usefulness, satisfaction, social influences, and attitudes, leading to a more effective strategy for promoting ChatGPT's usage. The findings confirm the significant influences of satisfaction, attitude, PCB, PU and PEU on continuance intention to use ChatGPT by students. The study underscores the influence of satisfaction, PU, attitude, subjective norm, and PCB on students' continuance intention to use ChatGPT. Further, the study highlights the role of confirmation and PU in shaping satisfaction, the role of PU and satisfaction in influencing attitude and the role of PEU and confirmation in influencing PU.

6.2 Practical Implications

The integrated model can guide the development of tailored educational strategies. Educators and designers can utilize insights from TCT and TPB to create training materials, user guides, and support systems that address students' perceived ease of use, satisfaction, and beliefs about ChatGPT's benefits. The results underscore the importance of focusing on improving the user experience of ChatGPT to enhance perceived ease of use and usefulness. Educators can be trained to use of ChatGPT for academic tasks. TCT emphasizes the ease of use and user-friendly features of ChatGPT. TPB highlights the need to enhance students' perceived behavioral control to build confidence in using ChatGPT effectively. Students can be encouraged to use ChatGPT by fostering positive subjective norms by involving influential peers, instructors, or experts who endorse ChatGPT as a valuable tool for academic work.

In sum, by integrating practical strategies informed by both Technology Continuance Theory and the Theory of Planned Behavior, educational institutions, developers, and administrators can enhance the adoption and long-term usage of ChatGPT among students. This approach emphasizes not only the technological aspects but also the cognitive, social, and motivational factors that influence students' intentions and behaviors.

6.3 Limitations and Future Research Avenues

This study is not without limitations. While we have tried to make this model holistic by incorporating both TCT and TPB, there could be more variables influencing students' continuance intention to use ChatGPT. Future research may incorporate factors such as technology skill, technology competency and digital literacy. Further there may be

variables that may act as moderators for this relationship. Future relationship may explore factors such as personal innovativeness that may moderate these relationships. Data collected is limited to students and future research may expand the sample so as to further generalize the findings. Finally, the current research is cross-sectional in nature and future research may be done longitudinally to uncover how these relationships change over time.

7 Concluding Remarks

Undoubtedly, ChatGPT is considered one of the most transformational artificial intelligence tools that has been produced in recent years. Understanding students' intentions to continue with it is crucial because it offers substantial opportunities in the education sector. Drawing on TCT and TPB, this study investigates students' continuance intention to use ChatGPT. The data was collected from undergraduate and post-graduate students and SEM was used to test the hypotheses. The study found that satisfaction, attitude, subjective norm, perceived behavioral control and perceived usefulness positively influenced students' continuance intention to use ChatGPT. These findings imply that technological and social factors play an important role in influencing students' continuance intention to use ChatGPT. We believe that our research outcomes will contribute to the expanding corpus of scholarly works on the application of artificial intelligence in the field of education.

Appendix A

The survey items are as follows:

Perceived Usefulness
Using the ChatGPT improves my performance in my learning.
Using the ChatGPT improves my productivity in my learning.
Using the ChatGPT enhances my effectiveness in my learning.
I find the ChatGPT to be useful in my learning.
Perceived Ease of Use
My interaction with the ChatGPT is clear and understandable.
Interaction with the ChatGPT does not require a lot of my mental effort.
I find it easy to get the ChatGPT to do what I want it to do.
I find the ChatGPT to be easy to use.
Satisfaction
My overall experience of ChatGPT use was: very satisfied.
My overall experience of ChatGPT use was: very pleased.
My overall experience of ChatGPT use was: very contented.
My overall experience of ChatGPT use was: absolutely delighted.
Confirmation
My experience with using ChatGPT was better than what I expected
The service level provided by ChatGPT was better than my expectation
Overall, most of my expectations from using ChatGPT were confirmed.

Attitude
Using ChatGPT for learning would be a good idea.
Using ChatGPT for learning would be a wise idea.
I like the idea of using ChatGPT for learning.
Using ChatGPT would be a pleasant experience.
Continuance intention
I intend to continue using ChatGPT rather than discontinue its use.
My intentions are to continue using ChatGPT than use any alternative means.
If I could, I would like to continue using ChatGPT as much as possible.
Subjective Norm
My friends approve of my decision to use ChatGPT
My close family approve of my decision to use ChatGPT
My colleagues and peers approve of my decision to use ChatGPT
I feel social pressure to use ChatGPT
The people in my life whose opinion I value would think that I should use ChatGPT
Perceived Behavioral Control
It is possible for me to use ChatGPT
It is easy for me to use ChatGPT
I myself decide whether to use ChatGPT or not
For me, using ChatGPT is easy
If I wanted to, I could easily use ChatGPT

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Amazon Alexa and I: Exploring Factors Affecting Usage Behaviours and Patterns Over Time

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Abstract. The proliferation of Voice Controlled Smart Assistants (VCSAs) is increasing, and this is expected to continue in the future. There is much promise in how the growing capabilities of these Artificial Intelligence-powered devices can affect user experiences, usage and habit yet little is known about these areas. This study aims to contribute to knowledge in these areas by utilizing an interpretive philosophy and a qualitative approach. A tri-phased data collection process was utilized which included the collation of diary data from fourteen participants over an eight-week period. This short paper provides insight into the key findings identified which highlight: how usage evolves over time, and factors that affect this evolution. The paper also discusses further steps the researchers will take to progress this study.

Keywords: Voice Controlled Smart Assistants · VCSA · Usage · User behaviour

1 Introduction

Voice-Controlled Smart Assistants (VCSAs), commonly known as Artificial Intelligence (AI) powered smart devices, enable users to interact through verbal exchanges to complete tasks or access services (Schweitzer et al. 2019). Smart devices are begin- ning to revolutionise various domains in society; the term "smart device" encompasses both physical devices, such as smart lights, robot pets, smart cars, etc., and non-physi- cal, disembodied devices such as voice assistants, chatbots and more (Silver et al. (2016). The adoption and usage of VCSAs has witnessed significant growth over the past few years, with almost 4.2 billion VCSAs being used worldwide (Statista 2020). Popular devices such as Amazon's Echo Dot (Alexa), Google's Nest (Hey Google), and Apple's HomePod (Siri) have become household names (McNair 2019).

While commonly used for simple tasks like finding information about weather forecasts (Lopatovska et al. 2019), VCSAs also offer a range of capabilities that extend beyond simple tasks. However, despite the increasing prominence of VCSAs and subsequent research, there exists a research gap that warrants further investigation. The aim of our wider study is to delve into this gap by examining the factors that influence the

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usage and adoption of VCSA devices, and the retail and consumption opportunities such devices provide their users. The focus will be on the Amazon Echo Dot (Alexa) device. Through a longitudinal examination of the patterns and factors that have been noted to impact user usage over time - the extent and nature of anthropomorphism, and the dynamics of user-device relationships – the wider study will aim to contribute valuable insights into what influences and motivates the adoption and continued usage of VCSA devices. In this short paper, we present some initial findings from our wider study. Specifically, this paper focuses on usage patterns and behaviours surrounding VCSAs. The research question we will address in this paper is: *What factors and patterns influence the usage of the Alexa VCSA device and how do these evolve over time?*

2 Literature Review

Positioned by authors Simms (2019) as the fastest-growing user technology since the smartphone, the use of VCSA devices has grown exponentially, with Statista (2022) predicting up to 130 million users by 2025 in the US alone. As such, these devices present an enormous opportunity for researchers and brands alike, with such devices quickly becoming novel paths for not just daily tasks such as timers and entertainment, but also for the purchase of Fast-Moving Consumer Goods (FMCGs), groceries, and other low-involvement purchases (PwC 2019; Singh 2021).

Authors such as Aw et al. (2022) highlight the need for developing further understanding of how such devices are used, the impact they have on user behaviour, and the motivations behind why users adopt, interact with, and make use of VCSA devices and their voice-shopping capabilities. Authors Moriuchi (2019), Lopatovska et al. (2019), and Buteau and Lee (2021) have led research pertaining to VCSA adoption and usage, while authors such as Shepherd et al. (2015), Novak and Hoffman (2019), Schweitzer et al. (2019), Pitardi and Marriott (2021) focus on how usage is influenced by factors such as trust, anthropomorphism, and the relationships that develop between users and their VCSA devices. Authors such as Hoffman and Novak (2017), McLean et al. (2021) and Schweitzer et al. (2019) have noted that it is crucial to understand the ways in which users experience and interact with voice-based technology, so as to better understand the technology itself and the impact usage has on users' likelihood to make use of other capabilities such as voice-shopping.

At present, most of the information about the adoption of VCSAs, such as Amazon Alexa, comes from industry reports (Lopatovska et al. 2019), demonstrating that while VCSAs are widely available, research addressing the factors associated with their adoption is still in its infancy (Vimalkumar et al. 2021). As such, authors such as Rijsdijk and Hultink (2009), Porter and Heppelmann (2015), and Mani and Chouk (2016) also call for future research in this area, noting that while smart products have been highlighted to be revolutionising users' lives, little is known about the factors that influence the ways in which users adopt and use their devices and how such potential factors differ from those associated with the adoption and usage of traditional objects such as home appliances or computers.

Paving the way for academic growth in this area, authors such as Kowalczuk (2018), McLean and Osei-Frimpong (2019), Moriuchi (2019), Lopatovksa et al. (2019), Balakrishnan and Dwivedi, (2021), Buteau and Lee (2021), and Vimalkumar et al. (2021)

have begun attempting to fill this gap, with work primarily focusing on the ways in which users engage with VCSA devices, and the enablers and barriers to accepting and adopting such devices. In this area, authors such as Lopatovska et al. (2019), highlight common trends pertaining to the way users engage with their devices, with the need to complete simple tasks such as checking weather forecasts, playing music, and controlling other devices serving as a key motivation for adoption and the most common means of engagement. Further, authors such as Kowalczuk (2018), McLean and Osei-Frimpong (2019), Fernandes and Oliveira (2021), Pitardi and Marriott (2021) and Al-Fraihat et al. (2023) highlight key motivations for adoption to be: perceived ease of use, perceived usefulness, trust, and enjoyment, alongside social variables such as the perceived humanness (anthropomorphism) of the device, and its ability to provide social interaction.

Alongside Balakrishnan and Dwivedi (2021) and Vimalkumar et al. (2021), authors such as Moriuchi (2019), Kowalczuk (2018), Belanche et al. (2019) and Buteau and Lee (2021) and have continued to explore the area of adoption, grounding their research in the Technology Acceptance Model (TAM) (Davis, 1989) to further develop and understand the influences that serve as the foundation for users interacting with, and using, VCSA devices. While the TAM model has provided significant insight into the adoption of traditional technologies such as personal computers, mobile applications, eCommerce platforms, and social networking sites, the autonomous, authoritative and agentic capabilities possessed by VCSAs (Al-Fraihat et al. 2023), have caused authors such as Hoy (2018), McLean and Osei-Frimpong (2019), and Pitardi and Marriott (2021) to note that it may no longer be an adequate model in explaining behaviour towards such smart types of technology as VCSAs.

The application of theories such as the Unified Theory of Acceptance and Use of Technology (UTAUT) (Perry 2016; Roy et al. 2018), the Robot Acceptance Model (Wirtz 2018; Fernandes and Oliveira 2021), and the Artificially Intelligent Device Use Acceptance (AIDUA) theory (Gursoy et al. 2019) have further been used to analyse the acceptance of smart technologies. What is clear is that as technology continues to advance, it is essential to examine not only the patterns and frequency of users' interactions with VCSAs but also the underlying psychological, emotional, and social dynamics that shape these interactions. As such, it is apparent that further research into the factors and patterns that influence the usage of VCSA devices and how these evolve is required to further current understanding in this area.

3 Methodology

An interpretivist approach was chosen for this study due to its ability to assist in providing a diversified view of the phenomena that allows for a rich description and a clear understanding of the objectives, the humans involved, and the experiences that are had within their social context (Pham 2018). Furthermore, as this philosophy allows for research to be conducted in natural settings via methodologies such as ethnography, the researcher hoped to obtain more authentic information and investigate areas that could not be openly observed, such as thoughts, perceptions, views, feelings, and perspectives

(Pham 2018). on user behaviour in the areas of habitual usage, and voice-based consumption. A qualitative methodology was deemed suitable and, as such, was adopted within this study.

The data collection method of this study is tri-phased and utilised in the following order: questionnaires, diaries (written and verbal) and informal interviews. As per Siebert et al. (2020), the rationale behind this phased approach lies in its ability to look beyond a short-term experience or a single interaction to review, in depth, the individuals full experience and determine patterns and relationships that may occur over a longer period. The study utilised purposive sampling: 14 UK-based participants were recruited, 7 males and 7 females between the ages of 25–45 years. The researcher bought one Amazon Alexa Echo Dot device for each participant. Data was collected using diaries over an 8-week period. Thematic analysis was used due to its recursive nature and ability to allow the researcher to continuously review the data and update themes in light of new findings or newly emerging themes that merit additional attention (Mojtaba et al. 2016; Kiger and Varpio 2020).

4 Findings

The study sample was made up of 50% males and 50% females. 29% (4 of 14) of participants worked in the Digital Marketing sector, making up the majority of the sample. The second largest occupation was noted to be Education (22% - 3 of 14), followed by Engineering (14% - 2 of 14). The remaining participants worked in the Healthcare, Customer Service, Recruitment, Legal, and Administration sectors.

50% (7 of 14) of participants strongly agreed to enjoying using technology in general (not limited to VCSAs). Further, 64% (9 of 14) of participants strongly agreed to being comfortable using technology, with a further 57% (8 of 14) strongly agreeing to being confident when using technology. Below we present key findings from our initial analysis pertaining to our research question.

4.1 Evolution of Experiences Over Time

At the beginning of the study, the data highlighted that all users spent their first 1–2 weeks "***getting to know how to use the device and learning what it could do***" (**P5, Female**). In this context, most participants expressed instances where they faced challenges and required a more deliberate approach to engaging with their VCSA device. Such an approach was reflected by all of the participants, with participants such as **P6** stating in their first week: "***I'm warming up to it. Last week I was avoiding it but I'm starting to put a bit more effort in now and exploring what it can do.***" (P6, Male).

From week 3 onwards, 85% of the participants (12 of 14) noted that they had begun to use their device in selective ways – getting used to how the device interacted and responded, while developing usage patterns and making regular attempts to embed the devices skills, routines, and tasks as part of their day-to-day lives. This was highlighted by **P7** who said: "***…now that I am becoming familiar with how it [Alexa] responds, I usually get the type of response I was hoping for I have continued using my Alexa.***

in the same way. She and I are back to going through my morning routines and then just our regular interactions The Alexa is beginning to become a part of my every-

day life. This is still going slowly, but I am becoming more confident with using the device." (P7, Female).

Participants used their devices in four main ways – for entertainment, assistance, information retrieval, and insight into processes. For half of the participants (7), assistance based tasks such as the use of morning routines, setting timers, asking about the weather, etc. served as the foothold for their habitual usage and were the most common tasks completed on a regular basis. Entertainment-based tasks and skills were also very common, with 9 of the participants habitually using their device as a means of entertainment (playing music, audiobooks, games, etc.), over the 8-week period.

By the final week of the study, the data highlighted a consistent pattern of participants habitually using their devices, with 11 participants noting that they were now in the habit of regularly using their device in patterns that fit into their lifestyle.

The development of habits, defined over the 8-week period is reflected by **P3** who notes: "***Alexa has become a part of my daily routine and I look forward to using it***". (P3, Female).

4.2 Perceived Benefits and User Experiences

The levels of utilitarian benefits (usefulness) highlighted by the participants had a significant impact on the types of experiences recorded. Throughout the 8-week study, data from each participant highlighted that the perceived usefulness of their VCSA device played a crucial role in shaping their experiences. When participants found the device to be useful in assisting with tasks, providing relevant information, or offering convenient functionalities, they reported more positive experiences.

The above is echoed by data from **P14** who demonstrated the role'usefulness' played in achieving positive experiences: ***"I find it surprising that we're 7-weeks in and I'm still learning new tasks and using new skills – makes me realise how absolutely useful Alexa actually is! I love when she prompts me to try new things and it's so satisfying adding another skill to my list of things we can do. I'm still using her the same ways I have been over the last few weeks – routines, timers, etc. - but it's always fun learning something new – keeps things exciting."*** (P14, Female).

When participants perceived the device as being less useful or encountered limitations in its capabilities, their experiences were often deemed as negative, specifically after a failed attempt at using the device or the feeling that it was not able to serve as a useful part of their daily life. For example, **P9** stated: ***"I'm not that satisfied with the device as I can't yet see a way it can make my life easier day to day at this current time***.". (P9, Male).

4.3 Emotions and User Experiences

The data also highlighted emotions as playing a crucial role in the shaping of the users' experiences with their VCSA device. Here, the study's findings revealed a direct correlation between feelings of emotion and the types of experiences noted, with positive

emotions commonly resulting in positive experiences, and negative emotions commonly resulting in negative experiences. For example, **P14** stated: ***"Every time I successfully use a new skill, I feel really happy and motivated – similar to completing a job or task."*** (P14, Female).

The impact of negative emotions felt on user experiences is demonstrated by data from **P5,** who in the early weeks of the study noted: "***I find the device misunderstands my question at times and will give information on what it thinks I asked. It is frustrating trying to interrupt to have it stop giving the wrong answer. Usually I have to repeat 'Alexa, Alexa, Alexa.' before it will listen and respond.***". (P5, Female).

Data from **P5**, **P7 and P8** also echoed the correlation between negative experiences and emotions felt, stating in week 2 and again on several occasions through the study: "***…In order to get my playlist to play I have to ask several times, while pronouncing my name in different ways. Usually after a 4th pronunciation it understands and plays my playlist. This makes me feel stupid and like it doesn't know me.***". (P5, Female).

Alongside the development of habits over the 8-week study, the usage-related data revealed an emerging theme regarding participants' likelihood to continue using Voice-Controlled Smart Assistants (VCSAs) in the future or post-study. The analysis uncovered consistent patterns in participants' usage behaviours and their expressed intentions to maintain or discontinue the use of VCSAs beyond the study period.

Data suggested that participants such as P3, P6, P7, and P14 who clearly demonstrated higher engagement, usage and frequent interactions with their VCSAs during the study were more inclined to express a desire to continue using such devices in the future. Additionally, the data showcased that habitual usage commonly resulted in a strong likelihood of future usage, specifically due to the participant's ability to learn more about their device and its capabilities.

For participants such as P10 and P14, habitual usage increased their confidence when using the device, allowing them to learn and make better use of its capabilities. Here, the data clearly demonstrates the correlation between the impact of continued usage and the participants' likelihood to use VCSAs post study. Both utilitarian and hedonic benefits were also noted to have a significant impact on the participants' likelihood to continue using the device post study.

5 Discussion and Conclusion

The research findings have provided insight into the key factors that contribute to changes in - and evolution of - VCSA usage over time. The development of habits played a crucial role in the evolution of usage patterns, with participants becoming more comfortable and proficient in utilising their VCSAs over time. This habitual usage was closely linked to the number of positive experiences reported by users, indicating a direct correlation between habitual usage and satisfaction with the device. Moreover, the influence of emotions on the user experience was evident, as positive emotions fostered greater enjoyment and engagement, while negative emotions led to dissatisfaction and frustration. Additionally, the types of experiences users had with VCSAs were also heavily influenced by the usefulness of the device, with successful task completion and personalised responses contributing to positive experiences.

Thus, the findings highlighted the importance of habit formation, emotions felt, and types of experiences in the evolution of the user usage of VCSA devices.

There seems to be a wide range of aspects that the diary entries have thrown up, many aspects of which merit further study. Thus, this short paper only touches upon one of the research questions that comprise the wider study by presenting some findings related to it. In doing so, the authors wish to use this as a starting point on which to investigate this topic further and would welcome the comments of the conference delegates with regards to advice on relevant theoretical frameworks/theories that may be used to contextualise a future study specifically dedicated to this theme. The brief literature review suggests that technology has much promise and existing models can provide a foundation for examining usage and behaviour. Indeed, some of the findings in this short paper can align with some of these perspectives. However, the findings also suggest that individuals are able to form new behaviours and habits, which can ultimately affect how they perceive and use technology. Next steps will involve further detailed analysis of the data in order to corroborate the themes identified in this paper.

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Digital Platforms and Applications

Analysing Platform Design Consideration to Ensure Digital Inclusion Among Indigenous People

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Abstract. This research paper explores the proliferation of digitally enabled business models, particularly in shared economy services and platform ecosystems. It examines the adoption of platform-ecosystem models by technology industry leaders and traditional incumbents. The study highlights the significance of data ownership in platform competitiveness and revenue generation. It investigates the impact of emerging digital technologies on the platform-centric business model. Additionally, the paper analyzes the challenges faced by shared economy services in reaching the BOP segment. The research questions address competencies fostered or inhibited by platform-driven solutions and strategies to encourage BOP usage of platform-based services. The paper includes an extant literature review, a mixed-method approach for data analysis, a discussion of findings, and conclusions with theoretical and practical implications.

Keywords: Platform ecosystem · Inclusion · Bottom of the Pyramid

1 Introduction

The proliferation of technologies has resulted in digitally enabled business models that share resources and have witnessed significant growth recently [28]. Shared economy services share underutilized resources to develop platform-based ecosystems. Recently, we have experienced various products and services being designed using digitally-enabled sharing economy models in transportation, hospitality or semi-skilled workforce and other emerging models. Shared economy services pivot around a digital ecosystem offering more flexibility and scaling scope.

Aside from those platforms that dominate the technology industry, incumbents in traditional industries are also adopting a platform-ecosystem business, either by developing a new platform or occupying an important position in an existing platform ecosystem. Studies have also investigated the challenges and strategies associated with setting up or scaling up a new platform ecosystem [15]. As the platform facilitates interaction between multiple types of users and has access to relevant data on them [14], data ownership plays

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an important role, both in nurturing the platform's competitiveness and as a source of new revenue. The recent proliferation of digital technologies such as blockchain, cloud and the Internet of Things (IoT) has given rise to research focusing on their impact on the platform-centric business model and research that focuses on exploiting those technologies with the help of the platform business model [1, 9]. Before many studies on digital platforms emerged, product platforms and their application in new product development had caught the attention of innovation researchers [2].

From the above, it can be seen that multiple researchers have focused on different aspects of platform ecosystems and offered a fragmented and sometimes contradictory conceptualization of them [3]. Given the diversity of research that has emerged, as well as the rapid pace of development of the field, a critical analysis of published literature offers an opportunity to consolidate the findings and understand the segments in which shared economy services have not been able to make adequate penetration. For example, that amongst indigenous people constitute the so-called the 'Bottom of the Pyramid (BOP)' in several regions and countries across the globe, which more appropriately may be referred to as the 'Base of the Pyramid', as in [30], as the impact can be looked at more from the foundational perspective. In the remainder of the paper, BOP will be referred to as 'the Base of the Pyramid'. Challenges to emerging business models have been in the form of social viability, acceptability [4], and identity [5]. The challenges will be interesting to study for the BOP segment. The following research questions have been explored in this study:

RQ1.How does a platform-driven solution foster or inhibit competencies in a context characterized by those at the BOP?

RQ2: How shared economy service providers can encourage the usage of platform-based services among the BOP people?

The paper is presented as follows: Sect. 2 presents an extant review of the literature to identify the subdomains within the diversified platform literature, which can then be used to identify gaps in our present understanding. A mixed-method approach has been used in this study, presented in Sect. 3. Section 4 presents the data analysis and the results. Section 5 presents the discussion with theoretical and managerial implications of the findings along with possible limitations of this study. The last section (Sect. 6) is the conclusion with an outline of the scope for future research.

2 Theoretical Background

India is one of the most diverse nations in the modern world. Its uniqueness lies in the assimilation of cultures, customs, ethnicities, languages, religions, and social structures spread over 700 [31] different tribes in an area of 3.28 mil square km across a population base of over 1.3bn. The north-eastern part of India[1], with 220 ethnic groups and an equal number of dialects, is by itself one of the most culturally diverse areas of the world [32]. Such regions, which have remained secluded for a long time, can contribute meaningfully to the country's growth through mass-scale inclusion into the economic mainstream [4]. However, unlocking this diversity dividend is crucially dependent on investments in

[1] Cluster of eight States—Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim and Tripura.

physical and social infrastructure to unlock the human capital available. The region, however, is plagued by literacy rates lower than the national average, compounded by higher dropout rates. The dropout rates in primary levels are over 17%, while that in upper primary levels is as high as 25.5%. For some states, like Arunachal Pradesh, Nagaland, and Manipur can be above 30% [33]. Several reasons lead to this kind of unfavorable outcome despite varied policy efforts[2]. These include the realities of school accessibility due to natural geographical barriers and lack of infrastructure, besides the usual challenges of economic, academic, linguistic, and social barriers.

Globally, the BOP segment constitutes a significant number of around four billion or more people whose daily sustenance is $2 per day or less [6–10]. This translates to an opportunity for organizations to target this segment globally [11], having significant purchasing power. Researchers [13] have undertaken studies to address this segment through innovative business models. This saw the emergence of digitally enabled shared economy services in resource-constrained environments [14, 15, 21] along with the challenges and opportunities. The ability to optimize limited resources in a shared environment is more challenging for the communities that come under the BOP. Diversity is an important characteristic of the BOP segment and hence, dissection in the form of creation of a segment will help us better understand this market as well as address the needs of this community. Extant literature has recognized the diverse grouping within the BOP market that is primarily based on demographic variables [18, 19, 22, 23, 29]. Consumer segmentation solely based on demographic variables has also been objected particularly in the context of emergent digitally enabled business models.

Previous researchers opined that, in this segment, consumers differ in aspects like lifestyles, personalities and needs [11, 12, 14, 15]. Heterogeneity exists within the BOP markets. However, there is not adequate research that offers any insight into the segmentation of consumers in this group of population.

Published literature based on studies undertaken for the BOP segment reported variations in context or approaches taken and thus underlines the need for dissection of this segment [4]. Sometimes social capital is the most valuable asset in these communities. It is vital for social economy models designed for BOP communities to integrate digital technologies in a way that helps to leverage social capital while sustaining social cohesion within these communities [19, 26, 29]. Digitally enabled shared services models can facilitate the creation of new opportunities for socialization and supplement existing socialization activities [19]. These emerging models can leverage digital technology for social intermediation to reduce information asymmetry and transaction costs [19, 25].

Digital social innovators [30] extended the BOP segment to offer a more inclusive definition by referring BOP as the Base of the Pyramid (BOP) and suggested innovative models to address social issues, including poverty and social exclusion. This segment can initiate activities that can generate livelihoods and, in the process, empower the

[2] Like Sarva Shiksha Abhiyan ('education for all' initiative) launched in 2001–02 where state governments have been making attempts to provide free, compulsory and universal primary education, intended to bring a large number of children under the ambit of school education. Besides, there were initiatives like the establishment of the National Open School (NOS) in 1989, which was re-designated as the National Institute of Open Schooling (NIOS) as a teaching, examining and accrediting organization.

community to have self-sustaining income generation [19–21, 24, 25]. Emphasis was on sharing, which can be deepened (i.e., more multiway sharing on the same service/product) and broadened (adding multiple services and products on the same platform) by leveraging digital platforms for sharing [16–19, 21]. Even though there is some early understanding of digitally enabled sharing economy models for BOP [28], this stream of research requires more exploration of how these models can evolve to be self-sustainable in resource-constraint environments like that of BOP and the role that technology can play in structuring these models.

3 Research Methodology

This study explored the facets of platform ecosystem design that can facilitate more adoption of shared services offered through digital platforms to the subscribers at the BOP. The ecosystem design research is still evolving, so a midrange approach can align multiple theoretical frameworks and concepts of resource integration, value co-creation, and value determination within an ecosystem. Midrange theory helps synthesize a subset of a phenomenon in specific contexts by contextualizing theoretically grounded insights to practice. The researchers have used qualitative and quantitative methods to gain insights into the research questions by conducting focused group interviews with indigenous people belonging to tribal communities in the northeast States of India for data.

4 Data Analysis and Results

The study explored the research questions as to how a platform-driven solution fosters or inhibits competencies in a context characterized by those at the BOP and how shared economy service providers can encourage the usage of platform-based services among the BOP people. An in-depth analysis of results indicates that for subscribers at the BOP, aspects of digital platform design and security are significant facilitators and inhibitors. This is more prominent among certain indigenous groups who feel that, given constraints related to the language in which the platforms are designed, a user-friendly platform design in indigenous languages is preferable for them for greater usability and adoption. The adoption is more pronounced among young subscribers (aged between 18–30 years) because of their exposure to platform-based services from an early age. Adoption in the age group 45–60 years is more timid as they tend to feel ‘digitally forced’ to use certain services that are developed in languages in which they are not so comfortable. Issues relating to security and the resolution of complaints about failed transactions and frauds have also risen significantly.

5 Discussion

Digital product and eco-system development involves creating and managing software, apps, platforms and websites from conception to launch and ongoing management. The products and ecosystem design should satisfy users and meet business goals which require business, design, technical, and ethical skills. The companies rolling out digital

platform-based businesses should be mindful of the stages of the product development cycle, from ideation and prototyping to launch and ongoing management. This becomes more significant to cater to sensitive ethnic groups who comprise the BOP.

Before the emergence of many studies on digital platforms, product platforms and their application in new product development had caught the attention of innovation researchers [18], multiple researchers have focused on different aspects of platform ecosystems and offered a fragmented and sometimes contradictory conceptualization of them [16]. Given the diversity of research that has emerged, as well as the rapid pace of development of the field, a critical analysis of the developments from the viewpoint of socio-technical imaginaries of service delivery can help us to address the research questions.

5.1 Theoretical Implications and Managerial Implications

In recent times several companies (established as well as start-ups) have started offering a range of products and services through digitally-enabled sharing economy models from transportation (Ola, Uber), hospitality (Oyo, Airbnb, Home Stay) as well as a diverse range of services such as a platform for the semi-skilled workforce (Urban Company) and other emerging models. Such new platform-based services pivot around a digital ecosystem that tends to offer more flexibility and scope for scaling. It has been observed that several platform-based companies tend to rely on a 'one size fits all' kind of digital ecosystem design without spending much effort and resources in tailoring them to distinct segments in society, like that of the customer segment at the BOP. Potential subscribers at the BOP tend to prefer and adopt platforms developed in languages in which they are comfortable. This requires more agile design development leading to a new type of organization setup and has been argued as the more preferred model in comparison to the classical model of integrated organizations [6]. Agility and modularity of business offer the flexibility of scaling along with sharing information and integrating with stakeholders, helping platform-based businesses to remain competitive. But, being new organizational forms, they also face social viability, acceptability, identity and legitimacy challenges. For managers, such challenges will be interesting to respond particularly for the BOP segment.

The critical aspect of the adoption and continual usage of platform-based services amongst people at the BOP is the divergent perspective between users at the BOP and the shared economy service providers concerning consumerization. BOP individuals have distinct personal discretion regarding the choice of mobile devices they procure and use. Shared service providers are more concerned about seamless usage and adoption and average revenue per user-related issues and security challenges. In this scenario, a 'one-size fits all' kind of strategy while designing and rolling out a platform driven for BOP and indigenous users requires in-depth study and analysis. The potential benefits and risks of the digitally enabled shared economy models have remained under-researched, particularly for the BOP segment.

5.2 Limitations of the Study

The study and its analysis have been based on data taken from tribal communities in the northeast region of India, which form a significant portion of the BOP segment in the country. There are geographical challenges and economic constraints in accessing digital facilities. The study may be replicated amongst other tribal communities from the country where accessibility is not so much a challenge as in the North Eastern region where this study has been conducted.

5.3 Conclusion

In conclusion, this research aimed to explore the design aspects of platform ecosystems that can facilitate the adoption of shared services by individuals at BOP through digital platforms. The study utilized a midrange approach, synthesizing multiple theoretical frameworks to contextualize insights into practice. The researchers employed qualitative and quantitative methods, conducting focused group interviews with indigenous people from tribal communities in northeastern India. The data analysis revealed that platform design and security significantly influenced the adoption of digital platforms among BOP subscribers, particularly among indigenous groups. User-friendly platforms in indigenous languages were preferred for greater usability and adoption, especially among young subscribers. The study also highlighted the importance of addressing security and complaint resolution issues.

From a broader perspective, digital product and ecosystem development require a combination of business, design, technical, and ethical skills. Companies launching digital platform-based businesses need to be mindful of the product development cycle and cater to the specific needs of sensitive ethnic groups within the BOP. The study emphasized the significance of analyzing the developments in platform ecosystems through the lens of socio-technical imaginaries of service delivery.

The research holds both theoretical and managerial implications. It highlighted the need for agile design development and tailoring digital ecosystems to distinct segments, such as the BOP, rather than relying on a one-size-fits-all approach. Agility, modularity, and information sharing were identified as key factors for the competitiveness and scalability of platform-based businesses. However, these new organizational forms face social viability, acceptability, identity, and legitimacy challenges, which managers must address, particularly when targeting the BOP segment.

Another important finding was the divergence in perspectives between BOP users and shared economy service providers regarding consumerization. BOP individuals have their own preferences and discretion when it comes to choosing and using mobile devices, while service providers focus on seamless usage, adoption, revenue generation, and security. Therefore, a one-size-fits-all strategy for designing and rolling out platform-driven services for BOP and indigenous users requires careful analysis and consideration of the potential benefits and risks associated with digitally enabled shared economy models.

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Understanding the Usage and Opinion Formation on LinkedIn: Uses and Gratifications Theory

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Abstract. Social media networking sites (SNS) provide multiple applications to individuals to fulfil their needs. This paper explores the LinkedIn platform's opinion formation, uses and gratifications and how professionals use it. The research aim was achieved by using LinkedIn data and social media analytics. We identified eight uses and gratification of SNS: information sharing, social interaction, communication, expression of opinions, convenience utility, surveillance/knowledge about others, information seeking, and enhancements. The study also establishes the associations between the type of content, user groups, and potential benefits to drive the discussion on the social media platform. The opinion formation and uses and gratifications on LinkedIn are associated with professional needs. This research contributes to practice and theory.

Keywords: Social media · LinkedIn · Opinion formation · Uses and Gratification theory

1 Introduction

The developments in computing, smart devices, and apps have transformed the interactions of society and technology. Social media networking sites (SNS) can be used for marketing, information sharing, connecting, and awareness. SNS have transformed how we interact, do business, and spend time on digital networks. Individuals and organizations have used SNS as a digital interface [1]. The use of SNS at individual levels has transformed social and cultural surroundings; however, the use of SNS by professionals does not seem to have equivalent changes due to various factors, including organizational social media networking policies, resources (software and hardware availability), balance between effective technology integration and participation incentives [2]. There have been multiple studies on SNSs, such as Facebook, Twitter, and YouTube [3]; however, there are limited studies on the uses and gratifications of SNSs like LinkedIn. SNS research studies have focused on technology aspects, SNS adoption, impacts on individuals, institutional culture, and support in organizational functions.

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This study describes SNS as the new technologies and apps that use the Internet and Web technologies to allow people to interact and engage in diverse communities through information sharing, chatting, collaborating, publishing, and interacting [1, 4]. This research is based on LinkedIn SNS. Existing research on LinkedIn focuses on opinion formation for individual or group interests [5–7] and LinkedIn's use for employment and HR practices. However, the multilevel usage of SNS by individuals, employees and organizations, and gratifications may influence marketing strategy design, collaborations, partnerships, B2B, and implementation of emerging technologies [1, 8, 9]. To understand the uses and gratifications of LinkedIn at multiple levels, we are answering the following research objectives.

1. To explore the uses and gratifications of SNS dedicated to professionals.
2. To explore the discussion on LinkedIn around an emerging technical domain, blockchain.
3. To explore opinion formation on the LinkedIn platform.

In this study, we analyzed LinkedIn data to understand the various types of content shared on LinkedIn related to an emerging technology, "Blockchain Technology". The analysis shows the shared content characteristics, user categorization, and uses and gratifications. This research contributes to the SNS usage by professionals and the uses and gratification theory use on LinkedIn platforms.

The paper is structured as follows: the first section briefly introduces the research. The second section provides research background, including literature on social media networking sites for B2B purposes and opinion formation, usage of LinkedIn, and theoretical background. The third section discusses the methodology. The fourth section presents the findings. The fifth section discusses the paper, its implications, limitations, and future scope. The sixth section concludes the paper.

2 Research and Theoretical Background

2.1 Social Media Usage

Corporates use different social media networks for different objectives. Social media use depends on the industry. Companies that directly communicate with the public use multiple social media platforms like Facebook and Twitter for feedback, communication, and product innovations. Companies use LinkedIn to recruit and communicate with employees' communities [10].

In terms of the usability of SNS, enterprises are increasingly interested in social media communication. Employees' own social media accounts regularly encourage company posts. The firms discuss the projects on social media and interact with project contributors. Professionals maintain their external and internal professional networks on LinkedIn [5].

The public-private balance of information on SNS varies. Facebook is an open public platform allowing users to create customized private platforms. LinkedIn's privacy policies and restricted platform structures are different. The administration carefully controls LinkedIn, where self-presentation is limited and driven by the user's network. Users must follow the platform's rules on different social networking platforms. LinkedIn and

Facebook offer different network management tools with varied degrees of control that users can utilize at their discretion [6, 10, 11].

The LinkedIn Platform Usability varies based on the region of the operations and users' groups. The LinkedIn platform is an SNS for professionals like corporates, entrepreneurs, academicians, and professional groups. Users of LinkedIn focus on employees, sharing information on opportunities available in the companies, and marketing purposes [5]. LinkedIn has been widely used for managing professional networks to have opportunities for individuals in their professional jobs. LinkedIn users have reported better professional benefits than the platform's non-users. Research shows that the users' engagement and network affect their professional opinions on the subject matter. However, it has also been observed that active participation on LinkedIn is not necessarily transcended to knowledge gathering by the individual by simply consuming the information [7].

The use of LinkedIn by entrepreneurs to promote their companies and the technical offerings as products and services have positive relations with tangible financial outcomes. Entrepreneurs use LinkedIn to establish connections, raise funds, self-promotion and boost their network [12].

2.2 Opinion Formation

The use of SNS has intrinsic and extrinsic motivations behind sharing content on SNS—the use of the LinkedIn platform for branding and reputations of corporate professionals as a virtual community. LinkedIn provides opportunities for users to build their networks. Along with reputation building and reciprocity as essential dimensions of sharing social media posts, technological knowledge is gaining significant transactions among users on SNS [13]. The information shared online influences opinions on social media platforms [3]. Companies and professional users are using SNS to influence the decisions of consumers. The following factors contribute to the persuasiveness of the authors in forming an opinion on SNS: the content's attractiveness, the author's credibility, and the sources' perception [14]. The research shows that the source of the content, context of the information and type of the content, for instance, posts containing simple texts, articles, photos, or videos, also influence the opinion formulation on SNS [15].

The research shows multiple studies on opinion formation on SNS, like Facebook and Twitter. However, there is limited literature on how professionals use professional SNSs like LinkedIn for opinion formation. With this research, we aim to explore how different user groups drive discussions on LinkedIn on a technical topic like blockchain and factors that contribute to opinion formation. This research adopts the uses and gratifications theory explained in the next section.

2.3 Uses and Gratifications Theory

The Uses and Gratification Theory (UGT) has its background in communication research [16]. UGT examines media consumption, why people use a particular media and its gratifications. UGT differs from other communications theories of its time, where traditional communications theories focus on the impact of media content on the audience [17]. Instead, UGT focuses on the engagement of users and interactions with social media

to fulfil their needs and goals. UGT illuminates the dynamic link between media and audiences, emphasizing people's active role in media consumption [18].

According to the UGT, people choose media to satisfy their needs and goals. The uses and gratifications of SNS [18] are the following: Social interaction, information seeking, Pass time, Entertainment, Relaxation, Expression of opinions, Communicatory utility, Convenience utility, Information Sharing, and Surveillance/knowledge about others.

3 Methodology

3.1 Data Collection and Analysis

a. Social Media Networking Platform- LinkedIn

LinkedIn is an SNS where users can share any form of content like text, images, and videos, and it also allows users to reshare others' content. The user interactions are measured by the number of views of the post, and the likes and comments can measure the attractiveness of the post. LinkedIn is a network-based platform where primary and secondary connections can see posts [5–7, 12]. It also has professional groups where users can share joint interests, come together, and share typical content.

This research collected data from the LinkedIn platforms of 1352 posts spanning 23 days. The #Blockchain keyword is used for post identification, and the following parameters (Table 1) have been captured for the LinkedIn posts:

Table 1. Parameters Collected for Analysis

Post Parameters	Author Parameters
Profile Links; Discussions; Shared Profile Links; Shared Discussions	Name; Tagline; Location; Summary; Contact_Links; Work; Experiences; Education details; Skills & Endorsements; Accomplishments; Interests

We received multiple forms of data from these posts and analyzed only text data from these posts: *Data collection:* The user data was collected using Python language script using Selenium libraries (Selenium library is used to automate browser testing). *Data cleaning:* It is performed to provide a state to data to analyze it.

b. Social Media Analysis Framework

The data collected is analyzed based on the Social Media Analytics model (Fan & Gordon, 2014), where the data is collected, monitored, analyzed, presented, and discussed to draw patterns and insights.

c. Data Categorization: This section categorizes data based on the authors, posts and technology applications. The analysis of LinkedIn posts into the following categories:

a. Entrepreneurs Entrepreneurs are founders of startups and working as freelancers and are not part of any corporate or academics. Other than the above categories, independent (independent of any organizations) miners, traders working in cryptocurrency and realtors working on designing the blockchain architecture are classified as entrepreneurs.
b. Corporates- Corporates category authors are associated with the corporates. In the corporate category, employees belong to different levels of hierarchy, including developers, designers, consultants, and hospitality staff. However, hospitality staff do not have any direct associations with blockchain technology development, while shared posts are part of their job requirement.
c. Academicians are faculty, researchers, and teachers working in schools, colleges, and university research centres. Students pursuing any academic degree when sharing the content, researchers, and research associates are also classified in this category.

Category 2- The content of LinkedIn posts is categorized into the following four categories.

a. Technology: The LinkedIn posts consist of information related to new technology, like posts related to mining, process, and implementation of distributed systems.
b. Product: The LinkedIn posts contain campaigns of new products to be introduced in the market or the features of a new product like a new software which implements blockchain solutions or helps standardize the blockchain platforms; cryptocurrency-related posts are categorized in this category.
c. Company: These posts and news are related to the company in the form of updates, technology solutions from the company, and events organized by a company that are also categorized as a company.
d. Self-Promotion: LinkedIn posts not falling into the above categories, and based on the marketing content types, are classified as self-promotion, like posts containing any certification done, events attended, and recruitment-related posts.

Category 3- LinkedIn posts based on technology applications are given below. The selection of blockchain helps to identify emerging trends within the organizations and how companies engage on SNS, highlighting how SNS users work on emerging technologies in their profession, promoting their work, business, and engagement within a background of emerging technology.

a. Crypto Currency- These posts contain information about initial coin offerings (ICOs) and cryptocurrency-related articles. Posts related to bounties and crypto mining are also categorized as Crypto Currency-related posts.
b. Smart Contract- These posts contain the use of blockchain for a contract platform for end-to-end security. Organizations and individuals use them for data exchange and to implement BPO processes.
c. Distributed Ledger- These posts contain blockchain applications of distributed ledger systems, like products based on distributed blockchain applications and asset ownership.
d. Other Applications- Other applications are not part of the above three categories, like Blockchain in IOT devices.

e. NA- Those posts that are not an application of blockchain but are related to blockchain are categorized as NA.

4 Findings

This study adopted the uses and gratification theory (UGT) to achieve the research objectives. The findings are arranged according to the UGT, which involves various factors for LinkedIn uses and derived values. Later, a framework was presented for opinion formation on the LinkedIn platform.

4.1 Information Sharing

Most posts explain blockchain technology using video, which was shared 51 times. During the research period, Blockchain Flash News (a media company based in California) posted 50 times informative posts on the blockchain. Investors and CEOs posted more content related to the company, freelancers and executives posted less, while users at entry-level positions were not promoting the company but products.

In terms of authors, there were 886 unique authors and the top five authors in terms of the number of shared posts were all entrepreneurs with more than ten posts shared. Information sharing on topic categories in percentage are technology (27%), self-promotion (27%), company (26%), and product (20%) related posts.

Technology topic posts were top technological trends and implementation of smart contracts in blockchain and automation using blockchain protocols. In the self-promotion topic, the highest categories of posts were related to certifications. Regarding the company topic, category posts were related to blockchain products, in which the Oracle blockchain solution platform was a prominent topic.

4.2 Social Interaction

The hashtag allows LinkedIn users to connect with professionals to share common interests. The hashtag used for the study is #Blockchain for getting posts related to blockchain. The users and the content of interactions drive the interactions on LinkedIn. The distribution of posts by the user group of the author categorized in this study: academicians, corporate professionals and entrepreneurs. There is no normality or homogeneity in interactions between these groups. Corporate sectors contribute highly to interactions, and academicians contribute the least.

The distribution of the data by content type represents the posts related to company, product, technology and self-promotion. The data distribution shows no homogeneity patterns, where discussion order starts with high on technology, company, self-promotion, and product. The interactions engage groups on various topics related to Blockchain technology on LinkedIn. Along with the blockchain hashtag, another 11 hashtags have more than 100 occurrences, and 6 of the top 11 hashtags used are related to Crypto Currency. The most common hashtags are blockchain, bitcoin, cryptocurrency, Crypto, technology, Ethereum, ICO, innovation, BTC, business, and trading, and three other hashtags are technology, innovation, and business.

Bitcoin is the second most popular topic, and LinkedIn posts related to blockchain technologies use the Bitcoin hashtag to gain more interaction with users' networks. Cryptocurrency and crypto hashtags are used for cryptocurrency topics to enhance interaction on their posts.

4.3 Expression of Opinions

The users express their thoughts and opinions and drive the discussion on blockchain topics on LinkedIn. Users post content related to the company, products, technology, and self-promotion on the LinkedIn platform. Individuals were promoting products like products were promoted by senior management, consultants, and designers, and they were responsible for the product's ownership. In contrast, media mid-level managers and professionals posted more about self-promotion. The realtors, miners and bounty hunters were sharing posts related to the technology available in the marketplace. The academicians were faculty and students, and they were promoting companies more compared to other categories. One of the reasons found by undergoing the profiles of these categories is that since blockchain is a relatively new concept and is more associated with corporates rather than academia, the posts related to company events and news updates are getting promoted.

The authors are categorized into different workgroups, as discussed in the Data Categorization section. The highest number of users are in Corporate (51%) user groups, indicating that professionals use LinkedIn to expand their professional network. The entrepreneurs are second with the user group constituting 43% of all the authors in this study. Academicians form a small user group on LinkedIn, with only 6% of the studied data group falling under this category.

4.4 Communicatory Utility

The users were driving discussion on LinkedIn on various aspects of blockchain technology. The following users shared content on LinkedIn, and Table 2 compares posts shared by different user groups. The active role in posts created and shared by executives, founders, consultants, and IT executives. Improved for founders and Bounty hunters (media professionals), whereas the shared post content is less for Managers and Executives, indicating a gap between motivation for sharing the posts for entry and mid-level professionals in corporates.

Users shared different content types on the LinkedIn platform (Fig. 1); when compared with the content composition, it is observed that Self-Promotion, like conference-related posts, has a higher probability of sharing, while product posts have a low probability. Both technology and company-related posts have the same probability of sharing.

The users shared posts on the applications of blockchain, where posts on cryptocurrency-related posts are shared less, and smart contract discussions have higher reachability.

Table 2. Comparing Shared Posts User Group with Study User Group

Activity	Bounty Hunter (%)	CEO (%)	Consultant/ Designer (%)	Executive (%)	Faculty (%)	Founder (%)	Freelancer (%)	Student (%)
Authored %	2.22	1.92	9.32	21.30	1.48	10.36	3.70	3.25
Shared %	3.51	1.92	9.58	17.89	1.68	13.34	3.27	4.23
Activity	Investor (%)	IT Exec-utive (%)	Manager (%)	Media (%)	Miner (%)	Realtor (%)	Trader (%)	Senior man-age-ment (%)
Author %	0.59	11.54	11.83	1.33	2.51	0.59	7.25	7.54
Shared %	1.20	10.62	9.74	2.32	4.39	0.56	7.91	7.35

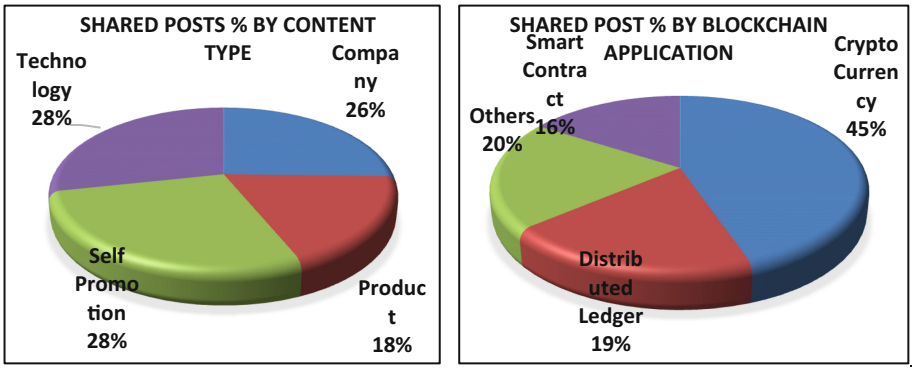

Fig. 1. Content Type (Left) and Blockchain Application Mentioned in Shared Post (Right)

4.5 Convenience Utility

LinkedIn enables users to connect with professionals worldwide and perform multiple functions using LinkedIn platforms, allowing them to influence multiple user groups for blockchain Technology. The entrepreneurs were driving their discussion towards the company, and the technology and founders were promoting their company. Entrepreneurs were also promoting themselves on the network, albeit less than their counterparts. The literature shows that a network is essential in funding startups, so founders connected and expanded their network. Corporate users are posting self-promotion posts, which allow them to use LinkedIn to boost their professional network, Job opportunities and self-promotion. Technology comes next in prioritizing the posts, which conforms to the above point. Companies and products were almost getting the same weightage rather than solely focusing on the company image.

The users can use LinkedIn platforms based on their convenience and what they want from the platforms. The academicians shared posts related to technology on LinkedIn. The research papers form an essential category for self-promotion of this category of users. The product and company have minor posts shared by the academicians as not aligning with their work gratifications.

The classification of posts based on what users' groups were discussing related to applications. The cryptocurrency had the highest posts, and entrepreneurs listed new cryptos. The corporates were promoting apps and platforms related to blockchain crypto solutions, and corporate employees were also promoting various educational materials related to crypto applications. The academicians were working on crypto processes as part of their research, inferred from the number of crypto posts shared on LinkedIn. Distributed Ledger gets approximately 20% of the posts by all user groups, and Smart Contract has fewer posts. The three user groups promoted the other applications, especially the blockchain, in an integrated Internet of Things solution.

4.6 Surveillance/Knowledge About Others

Users are looking for the kind of discussion and developments taking place in the blockchain space, and there are multiple interest groups; we have considered top interest groups on blockchain content posting. These interests of the authors were not necessarily converging with the professional workplace. Multiple posts were shared for a new platform introduced by Oracle for blockchain solutions, showing a concentrated effort to promote Oracle blockchain platforms. The authors' interests were associated with Microsoft, IBM, Accenture, Oracle, and Google as the first five interest groups out of 15. The association between the content and applications with the authors shows that user groups are looking for multiple interactions within their community.

4.7 Information Seeking

The presence of multiple technology groups and discussions on blockchain enable an environment for a platform to encourage various interest groups related to Blockchain technology whose members post about blockchain. LinkedIn users can seek information about new platforms, which provide blockchain solutions, new employment opportunities, collaboration opportunities, and self-learning on technology trends. LinkedIn user groups provide multiple information related to technology, products and services, and self-promotion. The top 5 groups related to Blockchain technology whose members post about blockchain are Blockchain, Athero, Bitcoin, Encrybit, and Ethereum. Professionals with a common interest in specific technology share technology content and applications on LinkedIn.

4.8 Enhancements

Enhancements show that actors use SNS to acquire resources to improve their skills, networks, and business opportunities. In this research, users' groups post and discuss on LinkedIn to improve their resources by showing their skills. In the case of academicians,

they were showing their skills by promoting their research, and they were part of multiple technology groups to learn about the latest trends in technology. In the case of companies and technology platforms, they showcase their products and services to enhance their businesses. At the individual level, they use LinkedIn to improve their opportunities by promoting themselves, their products, and their company and looking for opportunities to improve their existing skills.

5 Discussion

Multiple frameworks explain opinion formation on social media; however, these frameworks are restricted to a few SNSs like Facebook and Twitter. SNS research focuses on how companies and individuals influence users and the impact of social media [5, 6, 12]. This research tries to extend existing literature in the context of LinkedIn and drive theoretical contributions based on professional viewpoints and uses and gratifications theory. Based on the findings, uses and gratifications from the LinkedIn platform also contribute to the opinion formation model for LinkedIn. To understand the uses, gratifications, and opinion formation on LinkedIn platforms are associated with the type of content, authors, and network engagement. This research uses social media analytics to analyze LinkedIn data characteristics.

The opinion formation framework for the LinkedIn model is based on two essential factors: first, the context of the content, and second, the credibility of the author. The research content is technology, company, product, and self-promotion. The author's credibility is related to the author's reputation in his/her network and LinkedIn professional profile. However, the first part related to the network effect is out of this study's scope. This research maps the author's professional profile with three categories of profiling: corporate professionals, entrepreneurs, and academicians. It was found that particular user groups drive specific content on LinkedIn with a higher probability of driving opinions on LinkedIn. The concept of post sharing, which is almost in all cases, is positive reinforcement of the underlying context of the original post. The sharing of the posts also depends on the credibility factor of the original content writer, which is influenced by the professional profile.

The users have the following uses and gratifications from using LinkedIn: information sharing, social interaction, communicatory utility, expression of opinions, convenience utility, surveillance/knowledge about others, information seeking, and enhancements. The uses and gratifications provide an environment for opinion formation, which results in continuous interactions with an outcome of opinion formation and uses and gratifications to influence engagement.

This research also highlights the various interactions between the parameters of the post on LinkedIn. The post's content is strongly associated with the author and technology applications. The content distribution was not uniform to the authors and products due to multiple uses and gratifications sought from the post. The uses and gratifications of LinkedIn platforms have been associated with opinion formation. More than one construct of the uses and gratifications contributes to opinion formation. The interactions between UGT and opinion formation are bidirectional, where the uses and

gratifications construct serve to form opinions, and opinion formation further strengthens the associations between the UGT constructs.

Implications
This research explores the understanding of how different user groups and opinion formation are using LinkedIn. To the best of our knowledge, there is limited research on how companies and users from different professional categories use LinkedIn to form opinions. The findings showed essential insights for entrepreneurs for their use of LinkedIn. They can focus on the company features and products, technological platforms, and self-promotion. In the case of corporate professionals, they can focus on a hierarchical approach to engagement on LinkedIn. For instance, top management can focus on growth strategies and mid-level and entry-level employees can directly get involved with product development, sales, and marketing of the product and the service bundle. In the case of consumers, corporate consumers can explore the network of people for product promotion and the credibility of the founders, miners, and bounty hunters.

Limitations and Future Scope
This research is not without limitations. First, we did not discuss the network's response to the content posted on LinkedIn. Second, in some cases, qualitative research can support research findings to understand the how and why aspects of the patterns. Future research can explore the network analysis of LinkedIn data to explore the impact of the posts by analyzing the strong and weak ties of the networks.

6 Conclusion

This research shows the opinion formations and impacts of the SNS through the notion of UGT. UGT for SNS helps to identify the various reasons for SNS use. We have presented the logic of interactions on SNS by a specific community of professionals. We have taken a case of professionals using LinkedIn SNS to understand the logic of interactions, which reflects the usage patterns, gratifications, and implications. Along with uses and gratifications, opinion formation on LinkedIn platforms provides insights to practitioners and academicians to explore the strategies to connect for new networks, products, and technologies. We identified the following eight uses and gratification for SNS: information sharing, social interaction, communication, expression of opinions, convenience utility, surveillance/knowledge about others, information seeking, and enhancements. This research contributes to the academics, practice, and literature. With this study, we presented SNS usage and the roles of factors in opinion formation. These research insights can be used to understand SNS use, form business strategies, and how uses and gratification theory can be used with social media analytics.

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Blockchain-Based Application Security Versus Centralized and Distributed Data Management Systems – A Comparative Study

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Abstract. The current research aims to extend the existing literature on the differentiation of Blockchain Technology (BCT) from Distributed Ledger Technology (DLT) and traditional database management systems (DBMS) on grounds of providing additional security to user applications. Through a qualitative hierarchy methodology, it identifies prominent factors contributing to the same. 31 working professionals across a range of industry types were subjected to a semi-structured interview and the interview transcripts were analysed through NVivo and Rstudio. The findings suggested that the use of BCT in various daily use applications will drastically enhance security over traditional DBMS on grounds of traceability, immutability, transparency, accountability and non-hackability of data. The implementation of BCT over DLT in applications pointed towards enhancement of security too, but considering the areas only when the technical novelty of BCT is needed over the already robust DLT. While some industries would benefit straightaway, some need to strategically set their requirements on grounds of application security and think mindfully before implementing BCT considering the enhanced technical novelty of the same for visibly reaping its benefits.

Keywords: Blockchain · distributed ledger technology · database management systems · application security

1 Introduction

The participants in a business process are often connected to each other through distributed networks of complex communication mechanisms. The front-end of such mechanisms are often a website, a web portal or a desktop/mobile application which is accessed by the employees of the firm to conduct regular business processes or customers to access the firm's services. This interaction of the customers and the firm employees with the operational procedures, leads to the generation of information, which gets stored in various kinds of storage mechanisms. Majority of firms globally still use the conventional

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centralized databases for storing information which are dangerously prone to malpractices such as data theft, intended or unintended data loss, data manipulation and hacking of the entire database. As a result, users are concerned about the security flaws in mobile applications and the possibility that these applications include harmful code that might follow their online activities, steal personal information or conduct unauthorised and malicious activities (Kim et al. 2008). According to earlier research, behaviour of every stakeholder of the service provider firm must be taken into consideration in security studies since technological security measures alone are insufficient to safeguard users (Posey et al. 2014). For instance, Starbucks admitted in 2015 that hackers had used the Starbucks mobile app to access customer accounts, which resulted to many mobile customers being inconvenienced.

The introduction of blockchain brought to a change in the field of information storage and application security with the invention of "Bitcoins" (Nakamoto 2008). Chuen (2015), for instance, provided an example of how blockchain technology might be utilized to address privacy and security concerns in Industry 4.0. As it can do away with the requirement for a centralized authority to carry out various processes, blockchain technology has the ability to manage a variety of security assaults. A blockchain is the highest and most secure use case of the distributed ledger and since its transactions are connected by cryptographic keys and immutable ledgers, it is challenging for attackers to alter or remove the data that has been recorded.

In spite of the tremendous benefits of BCT, that it provides for data protection and application security, its implementation so far has been scarce due to reasons such as the costs of implementation involved, technostress, too much automation leading to job losses and additional training of the firms' employees (Malik et al. 2021). Although many studies have discussed about the great benefits BCT and its umbrella technology DLT has to offer to application security, majority of them has not drawn a clear line between these two technologies and have often used these terms interchangeably.

Therefore in this study, by interviewing 31 respondents who belong from industries where blockchain implementation has already taken place in some firm or the other, through a qualitative approach, we first attempted to establish the superior properties of BCT which would provide enhanced application security over a traditional DBMS. Further we also addressed the gap in the literature by further highlighting the differentiation between DLT and BCT, which is a use case of DLT, by again establishing BCT as a higher application security provider over DLT. This leads us to the following research questions:

RQ1. How does the implementation of Blockchain technology in applications enable higher security over centralized database management systems?

RQ2. How does the implementation of Blockchain technology in applications enable higher security over a distributed ledger?

2 Background

2.1 Application Security

The behaviour of users towards application security at both individual and organizational levels in IS research has been studies for mobile applications (Harris et al. 2016), internet and computer security (Shropshire et al. 2010), online transactions (Kim et al. 2008) and online shopping (Pavlou et al. 2007). Website security is one of the problems that online shopping websites face, especially when they are still in their infancy. In an online environment, consumers are mandated to share their confidential and financial information through applications or websites. This information can be abused by malicious actors overlooking the application if it is not guarded well from the back-end (Kim et al. 2008; Pavlou et al. 2007). How a user perceives the security of an application, can affect their behaviour towards the parent firm. Several companies have a problem with organizational security compliance because of perceptions of security (Johnston and Warkentin 2010). Some recent research suggest that application security concerns can be thought of as a construct comprising multiple dimensions that consist of management of data by the organization with whom consumers share personal information, awareness about current application security technologies and practices and the management of data between the organization and its third parties (Hong & Thong 2013). Numerous studies have shown that users' willingness to provide personal information (such as identity, location, and photos) to mobile apps, their intention to pay for those applications (Keith et al. 2015), and their intention to adopt mobile applications are all influenced by both privacy and security concerns.

2.2 Traditional DBMS

The DBMS searches the database for this data when an application programme calls a data file, then returns it to the application programme. The size and format of each data element used in the programme must be determined by the programmer when utilising conventional data files, and the computer must be informed of the file's location. To store the managed data, database systems need data files. These data sets are stored as files on storage devices. Traditional DBMSs are susceptible to online threats. Database security is the defence of information that must never be accessed from outside sources (Khanuja and Adane 2011). The information security that is feasible for computers and networks is database security. It refers to methods for making sure that information kept in a database can't be accessed or compromised by any people or organizations without permission. Attackers undertake attacks with the intention of achieving targets for their own gratification or financial gain. These assaults may jeopardise the availability, confidentiality, and integrity of data. The most common DBMS attacks include database injection attacks, denial of service (DoS) attacks, malware, exposure of backups, database misconfigurations, weak audit trails, inadequate permission management etc. (Medeiros et al. 2019)

2.3 Distributed Ledger Technology

A distributed ledger is fundamentally a digital, decentralized transaction database that is controlled by a group of nodes rather than a single server (Asante et al. 2021). DLTs run on peer-to-peer (P2P) networks that lack trusted administrators or centralised databases. Transparency, immutability, and censorship resistance are attributes of DLT. As a kind of DLT, blockchain (BC) is the most popular and commonly used but not all DLT applications will be symbolic of blockchain's unique characteristics. DLT has a wide range of commercial uses, including supply chain management (SCM), finance, agriculture, healthcare, and the energy industries (Asante et al. 2021). DLT also has the potential to address privacy issues. While DLT guarantees participant openness, it may not always be desirable to make sensitive information known to the whole network. This creates difficulties in industries like healthcare and finance where secrecy and privacy are crucial. To balance openness and privacy in DLT systems, more investigation and development are needed (Joo et al. 2023).

2.4 Blockchain Technology

A blockchain is a collection of interconnected blocks that may be used to share and store data in a distributed, open, and secure way. Each block contains data and uses pointers to connect to other blocks. These connections guarantee the blockchain's integrity and resistance to tampering. A new block is added to the existing blockchain that cannot be changed or removed by any other users. If one of the blocks in the chain is changed, the entire blockchain is disrupted because it destroys the cryptographic connections. The user can also confirm the accuracy of the data that has been stored. While majority of centralized cloud infrastructures are being deployed in SCM as IoT solutions, blockchain is utilized extensively in financial (Kar and Navin 2021) and cryptocurrency applications (Ahsan et al. 2023) as it improves the speed, security, usability, and secrecy of a variety of applications. Other domains where BCT adoption is increasing evidently are agriculture, healthcare, energy sector, supply chain management, digital content distribution, tourism and hospitality, logistics (Batta et al. 2021) smart cities, Internet of Things, manufacturing (Grover et al. 2019) and even constitutes the underlying technology behind the fast-evolving metaverse (Kar and Varsha 2023).

3 Research Methodology

3.1 Data Collection

The current study employs a qualitative data collection and analysis approach from 31 professionals working across various industries. A selective sampling approach was carried out to ensure that the respondents were working professionals, and the firms they worked for, had some sort of digital infrastructure for carrying out daily B2B or B2C operations through a webpage or a desktop/mobile application. Finally, their firms needed to have some sort of centralized/decentralized mechanism for storage of information generated from the firm's consumer-oriented or employee-oriented applications. Out of the 31 respondents, 19 were males and 12 were female and had an average work

experience of 3.5 years. Table 1 lists the number of respondents according to their academic background, the industries of the firms they are working at and their designation in their organizations.

Table 1. Profile of the respondents.

Academic Background		Industry		Designation in organization	
Masters in Technology	11	Financial/Banking	7	Senior management	5
MS	9	Computer Science/IT	7	Middle management	9
MBA	7	Agro-based	6	Security analyst	7
Bachelors in Technology	3	Manufacturing	4	Research & Development	6
Graduate (general)	1	Energy sector	3	Developer	2
		Healthcare	3	CTO	1
		Tourism and Hospitality	1	CXO	1
Total respondents = 31					

3.2 Data Analysis

The respondents were identified over LinkedIn and their respective telephonic interviews were conducted. The response rate was 17% and 83% did not revert back after initial contact. First, for each research question, text-coding of the interviews were done and were converted into transcripts by assembling the interview responses into individual response sheets. Next, the data was cleaned by eliminating numeric values, special characters and spaces from the transcript. The uppercases were converted to lower cases and stop words were removed. These transcripts were then analysed using NVivo. Thematic analysis was then carried out by first detecting and extracting codes from the interview transcripts (Braun and Clarke 2012). Themes were then generated by grouping the related codes under respective themes. As the codebook was being created to map replies to the themes that emerged from the interviews, intercoder reliability was established. These themes along with their count of occurrences and frequencies are depicted in Table 2 and Table 3. A word cloud was finally generated for each research question in Rstudio using the Quanteda package of R, which highlights the main contents or themes word-wise from the analysis. A team of 3 researchers were set up to establish the intercoder reliability and face validity. All of the three had prior research experience in management studies, out of whom, two were doctorates and the third, undergoing doctorate course.

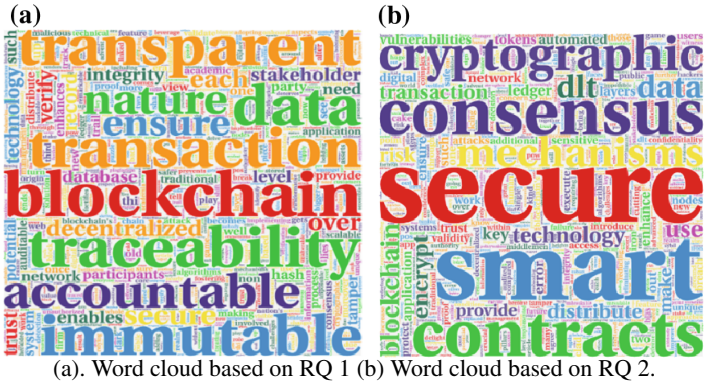
The intercoder reliability was established when mapping the pieces of texts of the interview responses with the themes emerging from the responses. Face validity was then set up through a group consensus-based approach.

4 Findings

The results of the analysis of the interview responses revealed two main categories regarding the implementation of BCT for added application security. The categories can be defined as blockchain technology providing considerably higher application security over traditional database management systems and blockchain technology providing an added edge over distributed ledgers but with minor concerns regarding justifications of the costs of implementation (Fig. 4).

4.1 Blockchain Technology in Applications for Higher Security Over Centralized Database Management Systems

The thematic analysis and word cloud (Fig. 1(a)) revealed that "transparent" is the word which is emphasized upon the most by the respondents, followed by "immutable" and "traceability". The other characteristics which the respondents considered to describe the justification of the implementation of BCT over a traditional DBMS are distributed, data loss, trust, accountability etc. While conducting thematic analysis, these words directed to the formation of themes.



(a). Word cloud based on RQ 1 (b) Word cloud based on RQ 2.

We considered the top five themes obtained from the thematic analysis of the first research question, which highlighted some key features of BCT which makes it superior over traditional DBMS when it comes to application security (Table 2).

The majority of responses were focused upon how a BCT can establish transparency between stakeholders (15%), how it can protect data in such a way that it cannot be tampered with, providing immutability (13%), at the same time, making information traceable on the blockchain (13%).

We have mentioned below some of the original instances from the respondents, as recorded over RQ1:

Table 2. Themes identified for research question 1

S. No	Themes	Frequency	Percentage
1.1	Transparency between stakeholders	24	15
1.2	Immutability of data	22	13
1.3	Traceability of information	21	13
1.4	Non-hackable	20	12
1.5	Accountability of all stakeholders	18	11
Top five themes having a frequency of more than two were included			

Respondent 15: Implementing blockchain over traditional databases enhances application security by enabling transparency and traceability. Blockchain's decentralized ledger records and verifies every transaction, providing a transparent view of data exchanges. Additionally, its immutable nature ensures an auditable trail, fostering accountability amongst all parties involved and reducing fraudulent activities. [1.1, 1.2, 1.3, 1.5]

The next evident themes were the non-hackable nature of the BC (12%) and accountability amongst stakeholders (11%).

Mentioned below are some of the original instances from the respondents over the aforementioned themes, as recorded over RQ1:

Respondent 4: By leveraging blockchain technology, stakeholders can track and verify transactions, ensuring transparency. Moreover, the distributed and immutable nature of blockchain prevents unauthorized changes, guaranteeing data integrity and making it nearly impossible to tamper with stored information. We too can now trust our third party vendors whom we onboard and in turn, customers can trust our firm. No blame-game will be involved as the accountability of all parties comes to play. [1.1, 1.2, 1.4, 1.5]

These findings are in accordance with the existing literature and extend the boundaries of the literature on the advantages of BCT implementation over traditional DBMS as well. Although nodes in the distributed blockchain technology have less connection, the network is still dependable and secure. The distributed database structure used by the blockchain technology decreases the danger of data theft and privacy breaches by storing data in encrypted form (Bodhke et al. 2020). Blockchain technology eliminates the need for middlemen and promotes trust by enabling transparent transactions and information exchange among stakeholders (Bodhke et al. 2020). Data becomes tamper-proof and unchangeable with blockchain, guaranteeing that once it is recorded, it cannot be changed, improving data integrity and dependability (Kamble et al. 2020). Hackers find it very challenging to undermine the integrity and security of stored data thanks to blockchain's decentralised and encrypted nature (Prakash et al. 2022).

4.2 Blockchain Technology in Applications for Higher Security Over a Distributed Ledger

As mentioned earlier, BCT is a use case of DLT, which makes every BCT a DLT but not every DLT a BCT. Therefore in the same manner as the first one, we obtained a word cloud out of the responses for the second research question as well and has been depicted in Fig. 1(b). This differentiation required high level of expertise from our respondents.

We considered the top five themes obtained from the thematic analysis of the second research question, which highlighted some key features of BCT which makes it technologically superior over a basic DLT when it comes to application security (Table 3). For RQ2, BCT seemed to dominate over DLT for application security only on the grounds of those noble technical features which makes BCT the best use case of DLT. It reveals that "cryptographic" is the word which the respondents mentioned the most, followed by "consensus", "tokenization" and "smart contracts".

Table 3. Themes identified for research question 2

S. No	Themes	Frequency	Percentage
2.1	Cryptographic encryption	32	22
2.2	Consensus mechanisms	26	18
2.3	Tokenization	25	17
2.4	Automation through smart contracts	25	17
2.5	Complete decentralization	22	15

Top five themes having a frequency of more than two were included

The respondents seem to be very keen on the fact that the fine line which differentiated BCT from a basic DLT is the cryptographic encryption (22%) it provides to the data, adding to application security. Also it comes with state-of-the-art consensus mechanisms (18%) such as PoW, PoET, PoS etc. which a basic DLT lacks. Respondents also laid emphasis upon the tokenization of data (17%) which is among the most crucial components that the blockchain must have. Mentioned below are some of the original instances from the respondents over the aforementioned themes, as recorded over RQ2:

Respondent 29: Many of those policymakers might not know this, but blockchain on distributed ledgers is like the icing on the cake. The cryptographic encryption and consensus mechanisms bring an iron-clad defence to application security. It's like bamboozling the hackers, making it nearly impossible to breach, safe and secure! [2.1, 2.2]

The next evident theme was the use of smart contracts (17%) and decentralization (15%). Mentioned below are some of the original instances from the respondents over the aforementioned themes, as recorded over RQ2:

Respondent 30: It's all about that tremendous cryptographic encryption, smart contracts, and complete decentralization. With blockchain, we make app security great again, ensuring data integrity and cutting out the middlemen. It's going to make a huge impact! [2.1, 2.4, 2.5] (Fig. 2).

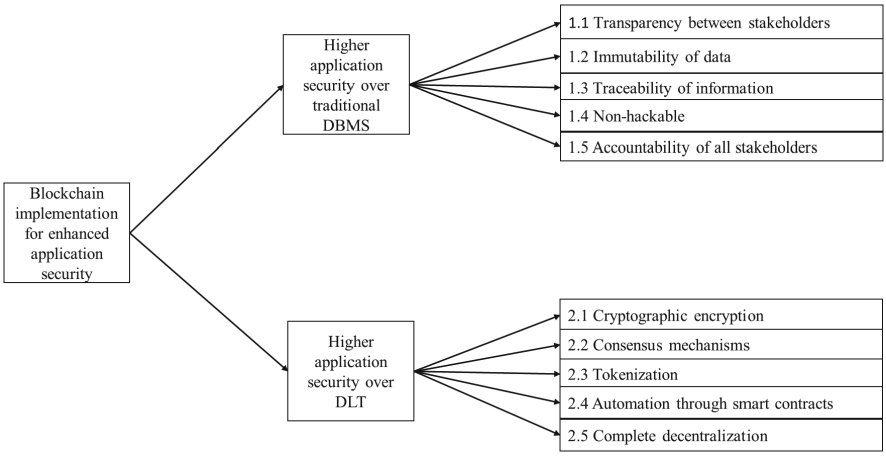


Fig. 2. Conceptual model of emerging themes for establishment of BCT for enhanced application security

These findings are somewhat in accordance with the findings by Asante et al. (2021) wherein the researchers have emphasized upon how BCT implementation can provide additional security in a distributed ledger system. The researchers have explicitly mentioned decentralization, transparency, immutability and process integrity as properties of a blockchain, which can completely cut off human intervention and make processes automated and trustworthy. By leveraging blockchain technology, stakeholders can directly interact and transact without the need for intermediaries, reducing costs and improving efficiency. Blockchain's robust cryptographic algorithms and consensus mechanisms provide a higher level of security compared to traditional databases, reducing the risk of unauthorized access and data breaches. Blockchain-based smart contracts automate and enforce predefined rules, reducing manual intervention and ensuring compliance, thereby enhancing operational efficiency (Wamba and Queiroz 2020). Bodhke et al. (2020) recognizes the differentiation between BCT and DLT and considers BCT the highest possible level of implementation of DLT.

5 Discussion

Although the contributions that BCT has made over various prominent fields such as supply chain management, healthcare and banking has been talked about extensively in literature, its contributions towards application security especially with regards to the already robust DLT has not been discussed much in academic literature. Therefore in this section, we highlight the areas where we extend the existing knowledge along with a discussion on the overall findings.

5.1 Theoretical Implications

One of the key contributions of this study is the establishment of a qualitative hierarchy of factors in BCT that significantly improve application security over traditional DBMS.

Transparency emerges as a critical attribute lacking in traditional DBMS, rendering operations opaque and prone to manipulation. BCT ensures transparent operations, making data immutable and traceable, reducing unauthorized access and hacking risks (Kamble et al. 2020). BCT reinforces data integrity and tamper resistance. Data entered by users remains unaltered. In traditional DBMS, a compromised centralized server can lead to data loss or its illegal sale on the dark web, whereas on a blockchain, hacking is increasingly challenging due to the need to control 51% of network nodes (Asante et al. 2021). Furthermore, the accountability of all stakeholders in BCT leads to collective consequences for actions, reducing errors and malicious intent (Bodhke et al. 2020).

A second notable finding clarifies the distinction between BCT and DLT, which has often been blurred in academic literature and used interchangeably (Joo et al. 2023). BCT has an edge over DLT. It involves cryptographic encryption of data stored through customer or employee applications, transforming it into information tokens (Bodhke et al. 2020). Consensus mechanisms and smart contracts automate processes, enhancing application security. In BCT, operations can be either centralized (e.g., private blockchains) or completely decentralized (e.g., public blockchains). Even if a stakeholder (node) is compromised in a blockchain, it does not threaten the entire chain due to the intervention of consensus algorithms (Wamba and Queiroz 2020). This highlights the fundamental properties of a distributed ledger in every blockchain, making it different from DLT.

5.2 Managerial Implications

Blockchain's enhanced application security, as revealed in the study, presents an opportunity for managers to rethink their data management strategies. The transparency and immutability of blockchain offers unparalleled protection against unauthorized access and data tampering, which is of utmost importance in today's data-driven world. Managers should consider integrating blockchain technology where security is a top priority, such as in supply chain management, financial transactions, and healthcare systems. By leveraging blockchain, organizations can significantly reduce the risks associated with data manipulation, fraud, and cyberattacks, ultimately fostering trust among stakeholders and clients. Moreover, this study emphasizes the need for businesses to stay updated with technological advancements. Investing in blockchain-based solutions can enhance application security, safeguard sensitive information, and ensure compliance with data protection regulations. This proactive approach to security can prevent costly data breaches and associated reputational damage.

6 Conclusion

This exploratory study, explores the possible ways blockchain technology can enhance application security over traditional DBMS and the DLT, specifically focusing on applications on end-user side and applications used in-house by firms to carry out daily operations. Prominent characteristics of the BCT which enhances application security in a traditional DBMS such as transparency between stakeholders, immutability and traceability of data, non-hackable architecture and accountability of all stakeholders are highlighted by employees of firms, whose industries have already integrated blockchain solutions in some country or the other.

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Struggle for Visibility: Mobilizing Dormant Logic on Social Media Platforms

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Abstract. Social media platforms often privilege dominant logics, marginalizing peripheral logics held by indigenous communities. Through a hermeneutic analysis of selling posts on the Facebook page, this research reveals the mechanisms employed by indigenous women entrepreneurs to activate their dormant logic and make it more visible and compatible with the dominant logic. The findings highlight two key mechanisms: denaturation, where collective identity is developed and separated from the dominant identity, and renaturation, where compatibility is sought between peripheral and dominant identities. Identity shedding and switching emerge as strategies for implementing the key mechanisms. This research contributes to understanding the power dynamics of logics in the digital space and offers insights into fostering inclusivity and empowerment.

Keywords: Social Media · Institutional Logics · Indigenous Women Entrepreneurs · Intersectionality · Hermeneutics · Praxis

1 Introduction

In the rapidly evolving digital landscape, social media platforms have become dominant spaces for communication, interaction, and economic transactions [8]. However, these platforms are often characterized by power asymmetries and the dominance of mainstream logics [4, 6, 19], which can exclude peripheral logics, such as those held by different marginalized communities [10, 11]. This exclusionary dynamic raises questions about how marginalized groups can mobilize their dormant or silenced logics to create more inclusive digital spaces.

This research focuses on the problem of power dynamics and exclusionary logics within the digital space, specifically examining how indigenous women entrepreneurs navigate dominant logic to make their peripheral logic more visible, accessible, and active. The intersectional identities of these women entrepreneurs, encompassing race, class, and gender, compound their experiences of marginalization [21, 23]. By engaging in entrepreneurial activities as a form of praxis [14, 17], they attempt to create spaces for their peripheral logic to thrive.

The study aims to shed light on the mechanisms through which indigenous women entrepreneurs mobilize their dormant logic and make it compatible with the dominant

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logic. We analyzed the activities of more than 300 indigenous women entrepreneurs operating through the *Dulili* (pseudonym) Facebook page. This research offers a hermeneutic account of their entrepreneurial praxis, delving into the storytelling techniques they employ in their online selling posts to convey their narratives and engage with mainstream audiences.

By exploring the entrepreneurial praxis of dormant-logic mobilization within the digital space, this research seeks to contribute to the broader discourse on digital inclusion, social justice, and the transformative potential of marginalized entrepreneurship.

2 Literature Review

A number of studies reveal power asymmetries in online settings. For example, power asymmetries are generated by customers' evaluations, and algorithms reproduce power asymmetries among different categories of actors [4]. Opaque algorithmic evaluations confine freelancers and gig workers within an "invisible cage" [19], while increasing carceral logics in social media platforms disproportionately punish minoritized digital users, such as Black women [10]. Additionally, app users' collective behaviors and practices can privilege certain norms and exclude others, perpetuating social inequalities [11]. However, how a marginalized group can mobilize their peripheral or dormant logic against the mainstream logic and create space to make it more inclusive is understudied.

Moreover, existing literature on institutional complexity mostly explains the consequences of conflicting institutional logics or how they can be maintained at the organizational level [18]. Studies have examined the reification of oppositional banking logics, hindering the diffusion of hybrids like Islamic banking windows [3], and the impact of hybrid staffing on the growth of Islamic bank branches [2]. The collision between scientific and commercial logics fragments organizational identity [24], while the clash of new and traditional workplace logics perpetuates gender inequalities [16]. Similarly, mchanisms for sustaining an "uneasy truce" between conflicting institutional logics have been explored, such as the coexistence of "business-like health care" and "medical-professional" logics [20]. Research has also delved into the hybridization of field-level logics by different actors [5, 26]. Organizations strategically combine conflicting logics in a number of settings, ranging from family firms to social enterprises [7, 13, 27].

However, the power relations involved in conflicting logics, particularly within the digital space context, have received less attention. Little research exists on how intersectional marginalized groups, with limited power to decouple [12] or delegitimize [25] dominant logics, activate their minority logics. There is thus a need to explore how these groups, facing intersecting forms of marginalization, mobilize their peripheral logics in digital spaces. By investigating the mechanisms through which previously dormant institutional logics are activated, this research aims to contribute to our understanding of a more inclusive and equitable digital space.

The goal of this paper is therefore to explore the mobilization of dormant logic by indigenous women entrepreneurs within the digital space and to understand how they attempt to make their peripheral logic more compatible with the dominant logic.

3 Methodology

The research context centers around a Facebook page called *Dulili*, which serves as a platform for digital intermediaries composed of indigenous women entrepreneurs. These intermediaries play a crucial role in linking other intersectional entrepreneurs with clients, facilitating the advertisement and sale of indigenous products to mainstream audiences. The products range from clothes and handicrafts to homemade organic products and jewelries, the designs of which are mostly inspired by ethnic minority motifs and patterns. The *Dulili* case has been observed over a period of two years, and a total of 3,800 online selling posts from their page were collected. These posts, in which the entrepreneurs employ storytelling techniques to promote their indigenous products, served as the primary textual data for analysis.

This research employs a hermeneutic approach to derive a richer interpretation of the textual data [9, 22]. Initially, the collected online selling posts were subjected to a preliminary analysis to identify recurring themes and linguistic strategies employed by the entrepreneurs. This initial analysis helped uncover insights and generate preliminary interpretations.

To further deepen the understanding of the context surrounding the posts and to gain a more nuanced perspective, in-depth interviews were conducted with the founders of the *Dulili*, who function as digital intermediaries. These interviews provided valuable insights into the entrepreneurs' motivations, challenges, and strategies employed in promoting indigenous products on Facebook.

The interview data provided us with rich insights on the basis of which a second round of text analysis was conducted. This iterative nature of the analysis enhances the interpretation of the textual data as well as the validity and richness of the findings [1].

4 Findings and Discussion

The analysis of *Dulili*'s selling posts revealed key mechanisms through which indigenous women entrepreneurs mobilize their dormant or silenced ethnic logic against the dominant and exclusionary mainstream logic, with the aim of fostering inclusivity within the digital space. This mobilization process, which we refer to as entrepreneurial praxis, is facilitated through the utilization of story-based selling posts. The main findings highlight two central mechanisms: *denaturation* and *renaturation*, which contribute to the activation and compatibility of the peripheral logic with the dominant logic.

Denaturation emerged as a critical process in the mobilization of dormant logic. In this process, the entrepreneurs first develop a collective identity centered around their shared experiences as indigenous ethnic women, prioritizing the collective over individual ethnic identities. Through this collective identity, they then separate themselves from the mainstream dominant identity. Denaturation thus occurs on *identity shedding*, a process through which entrepreneurs ultimately solidify their internal bonding and strengthen their collective identity.

Renaturation, on the other hand, involves leveraging the dominant identity and striving to make the collective identity of indigenous women entrepreneurs more compatible with the mainstream dominant identity for legitimacy. This process entails a constant

switching between the mainstream identity and their peripheral identity, wherein the entrepreneurs showcase the compatibility of their identity to gain acceptance and recognition. Renaturation thus occurs on *identity switching*, wherein the entrepreneurs strategically navigate between their peripheral identity and the dominant identity, establishing a sense of compatibility to align with mainstream norms.

Collectively, identity shedding in denaturation and identity switching in renaturation underscore the entrepreneurial praxis. Through this praxis, the digital intermediaries within *Dulili* play a pivotal role in guiding and supporting indigenous entrepreneurs in implementing denaturation and renaturation as mechanisms to mobilize their dormant logic within the digital space. These findings demonstrate the intricate process involved in logic mobilization and highlight the utilization of story-based selling posts that enables the indigenous entrepreneurs to effectively communicate their narratives.

The findings of this study make several important contributions to our current understanding of logic mobilization in the digital space, particularly within the context of indigenous women entrepreneurs. The study expands our knowledge of power dynamics and logics within social media platforms. It contributes to the literature on institutional complexity by focusing on the mechanisms of denaturation and renaturation as means to mobilize dormant logics. While previous studies have predominantly explored how conflicting logics can be pursued together [7, 13, 18, 20], this study sheds light on how marginalized groups actively engage in entrepreneurial praxis to create space for their minority logic. The conceptualization of denaturation and renaturation as key mechanisms expands our theoretical understanding of how peripheral logics can be activated and made compatible with dominant logics.

This research also contributes to the field of intersectionality by providing insights into how indigenous, predominantly poor, women entrepreneurs navigate the digital space and employ strategic identity practices to mobilize their dormant logic. The lens employed in this research contributes to a more nuanced understanding of how power dynamics intersect with multiple axes of identity within the context of digital entrepreneurship.

5 Limitations and Future Research

While this study contributes valuable insights, it is important to acknowledge its limitations. Firstly, the research focuses on a specific context, namely the activities of indigenous women entrepreneurs within the *Dulili* Facebook page. Given the specificity of the context, the findings may not be generalizable to other entrepreneurial contexts. Recognizing this limitation, future research could explore different settings and marginalized groups to gain a broader understanding of logic mobilization.

Secondly, the study relies primarily on the analysis of selling posts together with insights gained from interviews with *Dulili* founders. While this approach provides rich insights into the mobilization-mechanisms of digital entrepreneurs, it may exclude certain nuances or may not capture the perspectives of all relevant stakeholders involved in the digital space. To address this potential gap, future research could consider incorporating a wider range of voices, such as customers and other entrepreneurs, to obtain a more comprehensive understanding of logic mobilization.

Lastly, the research adopts a hermeneutic approach, which emphasizes interpretation and meaning-making. While this approach is well-suited for the purpose of this research, it is subjective to some degree [15]. Different interpretations are likely to arise from alternative perspectives, and the researcher's own biases and assumptions may influence the analysis. To address this limitation, efforts were made to maintain reflexivity and rigor throughout the research process.

6 Conclusion

The findings of this study provide valuable insights and strategies for indigenous women entrepreneurs seeking to mobilize their dormant logic within the digital space. By understanding the mechanisms of denaturation and renaturation, these entrepreneurs can employ entrepreneurial praxis to make mainstream, exclusionary logics more inclusive and accommodating. The findings offer guidance on how to navigate power asymmetries and powerfully communicate their narratives through story-based selling posts, thereby enhancing their visibility and market presence.

Digital intermediaries can also benefit from the findings by gaining a deeper understanding of their pivotal role in supporting disadvantaged groups. By drawing on insights from this research, intermediaries can enable marginalized factions to navigate power dynamics and find spaces of inclusion within the digital realm.

Additionally, this study can be a prompt to platform administrators to critically assess their algorithms and practices, and motivate them to work toward contributing to a more diverse and equitable digital space. Policymakers can also utilize the findings of this study to inform regulations and policies that promote inclusion and empower marginalized groups within the digital space. Recognizing the challenges faced by indigenous women entrepreneurs, policymakers can develop initiatives that provide support and resources to help bridge the power gaps and enhance their digital presence. Overall, the practical implications of this study extend to individuals and organizations striving for a more inclusive and equitable digital space.

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Does Women Mobile Technology Inclusion Shape Their Attitude Towards Intimate Partner Violence? An Empirical Evidence from Sub-Saharan African Communities

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Abstract. This paper investigates the relationship between women's mobile phone inclusion and their attitude towards Intimate Partner Violence (IPV) in the context of low- and middle-income countries from Sub-Saharan Africa (SSA), where mobile phones have seen massive adoption in recent years. We conceptualize the said relationship using the Theory of Conjunctural Action, the World Society Theory, and the IT Affordances Theory. This paper utilizes micro-level data from USAID Demographic and Health Surveys (DHS) and employs Ordinary Least Squares Regression to examine the said relationship. We supplement our micro-level analysis with macro-level cross-country evidence to show that our findings are generalizable to a broader mass. Our identification strategy relies on instrumental variable analyses (both micro- and macro-level) to deal with potential endogeneity concerns. Results from our empirical analysis reveal that communities with a higher proportion of women owning mobile phones possess less tolerant attitudes towards IPV. Our results are consistent for both micro- and macro-level analyses. Findings of our study highlight a vital role of mobile phone technology in challenging pre-existing mental frameworks among marginalized women by instantiating gender-impartial schemas through worldwide connectivity.

Keywords: Mobile Technology · IT Affordances · Theory of Conjunctural Action · World Society Theory · Attitude · Intimate Partner Violence

1 Introduction

"No society can unlock its full potential when half of its population is marginalized and disempowered" [4]. In essence, achieving Sustainable Development Goals (SDGs) becomes an arduous task without addressing the issues of gender inequality [4]. Over the years, policymakers have realized that eliminating gender inequality is unattainable without challenging the societal norms that negatively attenuate women's progress. According to UNICEF Global Database 2017, in lower- and middle-income countries, nearly 49% of women believe that wife

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beating is justified in certain circumstances [14]. This raises the question - why do women *justify*, *believe*, and sometimes *operationalize* forms of social action such as IPV that have deteriorating effects on their physical and psychological well-being? This can be understood by employing the Theory of Conjunctural Action (TCA), which introduces the notion of 'schemas', defined as *"unobserved mental maps through which we make sense of the world"* [6]. In the digital age, when these social interactions are predominantly enabled and facilitated through Information and Communication Technologies (ICTs), understanding the kind of shifts happening in their attitudes becomes crucial.

In the past two decades, there has been a significant global uptake of ICTs. This widespread adoption can be attributed to their potential in offering a range of functionalities that help individuals viz-a-viz organizations in day-to-day activities. ICTs provide numerous opportunities in terms of connecting people around the world, sharing opinions, raising voices against injustice, and more [10,17]. Among the existing ICTs, mobile phone technology has achieved massive global adoption, including in low- and middle-income countries (LMICs), even in regions where traditional ICT infrastructure remains inadequately developed [1,10]. This massive uptake of mobile phone technology in LMICs resulted in various socio-economic outcomes, especially for marginalized groups such as women, by facilitating access to - (i) real-time relevant information, (ii) staying connected with loved ones, and (iii) essential public services related to education, governance, and healthcare, etc. [1,10,13]. While not exhaustive, this list suggests the vital role of mobile phones in overcoming various spatial and temporal constraints, offering policymakers *"digital pathways"* for inclusive development [4].

Extant literature on the interrelationship between ICTs and IPV seeks to understand how traditional ICTs and print media shape women's attitudes towards IPV by providing relevant information and increasing connections among heterogeneous networks. For instance, Jensen and Oster [5] discuss how the introduction of cable TV increases women's autonomy and, consequently, decreases acceptance of IPV among women. Banerjee et al. [3] found a significant effect of edutainment on shaping attitudes of both men and women towards IPV. The findings from Uthman et al. [16] suggest that women who read newspapers are less likely to exhibit tolerant attitudes towards IPV. The existing literature examines the said relationship, particularly in the context of traditional ICTs, such as radio and television, and print media, such as newspapers. However, based on our literature survey, we found that the existing literature is limited in examining this relationship in the context of mobile phone technology that offers worldwide connectivity, unlike radio or television with geographical constraints. This motivates us to explore the following research question:
Research Question: *Does women mobile technology inclusion shape their attitude towards Intimate Partner Violence (IPV)*?

To answer the proposed research question, we have drawn from the TCA, World-society theory (WST), and IT Affordances Theory [6,7,12]. Guided by these

theoretical lenses, we propose a theoretical framework. We hypothesize that the mobile phone as a material element instantiates new schemas and alters existing ones based on global cultural scripts that promote gender equality. This is achieved through providing access to relevant information and facilitating social interactions among heterogeneous networks. To test this hypothesis, we have taken the USAID Demographic and Health Surveys (DHS) dataset from seven LMICs from Sub-Saharan Africa (SSA), based on data availability [15]. We have taken the proportion of women's mobile phone ownership at the community level as an independent variable, and women's attitudes towards violence aggregated at the community level as our dependent variable. To address endogeneity-related concerns, we have also performed Instrumental Variable analysis using average lightning strikes at the community level from the high-resolution full climatology (HRFC) dataset [9]. The results from our analysis suggest that communities with a high proportion of women having mobile phones possess less tolerant attitudes towards IPV among women. We supplement our analysis with cross-country data, and our estimates are consistent with the results from our primary (micro-level) analysis. To the best of our knowledge, only a limited number of studies have explored the role of shaping attitudes as a potential catalyst for development. In this vein, our research aims to shed new light on this transformative perspective, resulting in multi-fold contributions. Firstly, our study contributes to the existing ICT4D literature by proposing a theoretical framework that integrates traditional sociology theories (TCA and WST) with IT affordances theory. This framework highlights the role of mobile phones in instantiating schemas aligned with global cultural scripts that promote gender parity by virtue of their affordances. Secondly, our work contributes to the literature of gendered studies, shedding light on the intricate ways mobile phone inclusion can shape women's attitudes that govern the existing authoritarian structures between intimate partners. Shaping attitudes poses a significant policy challenge, and many policy-side interventions targeting poverty alleviation and women empowerment often falter due to the prevalent attitudes alone [4]. In summary, our findings demonstrate the potential of mobile phones as a strategic precursor to broader developmental initiatives, offering a more promising avenue for transformative change and fostering inclusive development.

The rest of the paper is organized as follows. Section 2 provides the theoretical foundations and formulates the hypothesis. Section 3 discusses data sources, variable construction, and the methodology. Section 4 presents the results of our empirical analysis. Section 5 discusses the implications for policymakers and limitations. Lastly, Sect. 6 concludes the paper.

2 Theoretical Foundations and Hypothesis Formulation

To explore the relationship between women's mobile phone inclusion and their attitude towards IPV, we adopt a *technological determinism* perspective. This perspective considers technology as a *driving force that reshapes society and organization,"* contrasting it with the voluntarism dichotomy that perceives technol-

ogy as a *force whose development and utilization is under the control of management* [7]. Our assumption is particularly relevant in the context of mobile phone adoption in least-developed nations, where individuals have no direct involvement in the development of mobile phones and their behaviours pertaining to mobile phone 'utilization' are primarily shaped through *exploration and imitation* exercises rather than formal and structured learning processes. Figure 1 represents the theoretical framework employed in our study.

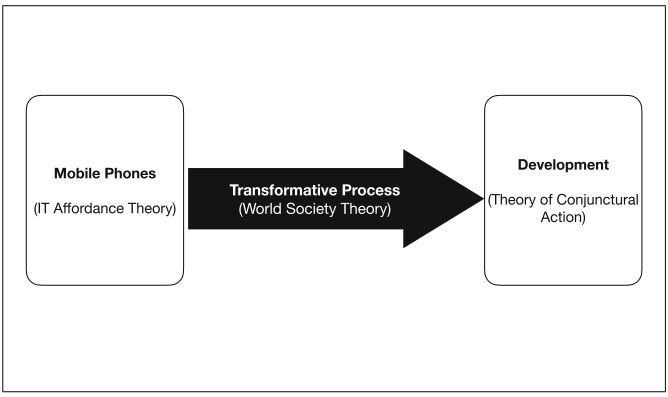

Fig. 1. Theoretical Framework

2.1 Structures, Schemas, and World Society

We have employed the TCA and WST to conceptualize the linkage between women's mobile phone inclusion and their attitude towards violence [6,12]. TCA draws upon the structuration theory and emphasizes the role of social structures in shaping and directing social action [6]. The social structure is defined as the product of interaction between schematic and material elements over time. The schematic elements are defined as *"ways of perceiving and acting through which we make sense of the real world"* and are reinforced and shaped by interacting with material elements. The material elements are the *"objects, performances or organizations that instantiate at least one schema"*. For instance, in our case, a mobile phone, as a material form consisting of a specific hardware and software configuration, can instantiate schema through a wide range of functionalities. Hence, it can be considered as a material. According to TCA, people do not encounter a single structure alone or a complex structure in its entirety. Instead, they face 'conjunctures', i.e., short-term specific configurations of structures where social action occurs. The social action occurs as an outcome of the construals, referred to as *"a mental process through which individuals perceive and interpret things"* using pre-existing mental frameworks, i.e., schemas.

These construals are routinized and can only be scrutinized under transformative events when conjunctures become ambiguous, i.e., not construable under existing schemas [6].

The world-society theory from sociology seeks to explain the diffusion of global culture and shared norms across boundaries [8]. According to this theory, over the latter half of the twentieth century, liberal individualistic principles emphasizing equality gained cultural authority. As nations are embedded within the world society, it encourages them to adopt cultural scripts that are accepted globally [12]. The diffusion process occurs through increased social interactions facilitated by material elements.

2.2 Mobile Phone Affordances and Instantiation of New Schemas

We examine the mobile phone as a material element that can take complex material forms as it can potentially instantiate a wide range of schemas by providing information and facilitating communication worldwide. We draw upon IT affordances theory to discuss the potential ways mobile phone technology affords the instantiation of schemas. The existing IS literature defines material elements (i.e., materiality) as something that has 'matter' and 'form' together [7]. Leonardi et al. [7] discuss how material elements like mobile phones (as an ICT) *"exercise agency through their performativity, i.e., by doing things that humans cannot completely or directly control"*. However, material elements do not possess intentions and help human actors to realize their intentions. Due to the lack of intentionality, the same material elements may exercise different levels of agency when approached by different actors, i.e., material agency. Thus, the material elements are functional to the realization of social consequences, both desired and unintentional, by affording those consequences [7].

In the context of IS, the affordances are defined as the *"possibilities for action that depend upon the material properties of an object, and the ability of actors to perceive and operationalize those possibilities"* [7]. Thus, the material properties are the necessary conditions for the existence of affordances but not the affordances themselves. When women as goal-driven actors approach mobile phones, it affords social action that might not be possible without mobile phones. The existing IS literature classifies these mobile phone 'affordances' into three networking dimensions: economic, social, and governance [11]. Mobile phone affords these networking dimensions by virtue of increased access to relevant information timely and increased possibilities for connectedness [11]. Firstly, mobile phones provide access to relevant information that exists in the form of digital entertainment (exhibiting charisma), formal documents (exhibiting legitimacy), or narratives on digital social spaces (exhibiting persuasion) that depict or unravel the position of women in the household and ultimately the society [11]. Secondly, mobile phones increase connection possibilities in terms of strengthening existing relations and fostering a new set of relations [11, 13].

Based on the preceding discussion, we posit that mobile phones can potentially challenge existing schemas and can instantiate new schemas based on globally accepted cultural scripts, including gender-impartial perspectives, through

two primary ways. Firstly, with increased exposure to diverse information that exhibits *charisma, legitimacy, and persuasion*. Secondly, with increased interactions among *heterogeneous networks* using multi-media channels. Based on this, we hypothesize,

Hypothesis: *Communities with higher women's mobile phone inclusion exhibit less tolerant attitudes towards Intimate Partner Violence (IPV) among women.*

Basis the hypothesis, we have created a conceptual model, as shown in Fig. 2, for our empirical analysis. According to this model, the communities with higher women's mobile phone inclusion exhibit less tolerant attitudes towards violence. The following section will discuss the data and methodology used in our study.

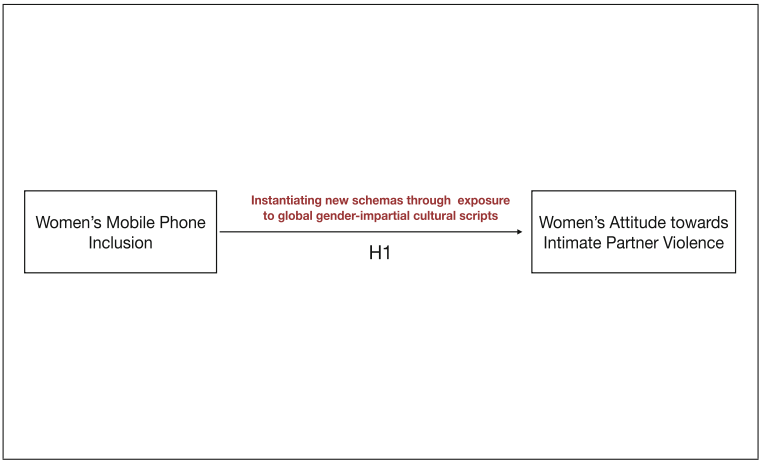

Fig. 2. Conceptual model used in analysis.

3 Data and Methodology

3.1 Data and Variable Construction

To test the hypothesis formulated in the previous section, we employ publicly available and nationally representative secondary data from USAID Demographic Health Surveys (DHS) Program [15]. The DHS conducts comprehensive surveys of women aged between 15–49 and men aged between 15–60. We have employed the DHS Phase-VII (2015–2016) data for seven LMICs from SSA - Angola, Burundi, Ethiopia, Malawi, Tanzania, Uganda, and Zimbabwe [15]. The underlying reason for taking only LMICs from SSA is to maintain the internal consistency of our findings. We have validated the generalizability of our findings by supplementing our primary analysis with macro-level cross-country data

(provided in Appendix A). We have only considered those women who have fully completed the DHS interview. We have aggregated the individual-level characteristics to the community level because our theoretical lens puts a significant degree of emphasis on social structures that shape social action. A community in our study refers to a DHS cluster comprising 25–30 households.

Table 1. Descriptive statistics

Variable	Mean	SD	Min	Max	Observations
ATVF	0.428	0.274	0	1	4428
MPOF	0.415	0.294	0	1	4428
EDUF	5.649	2.928	0	14.634	4428
HHSZ	2.166	0.885	0	6	4428
CWSF	0.622	0.262	0	1	4428
RDIO	0.462	0.238	0	1	4428
TELV	0.249	0.325	0	1	4428
URBN	0.309	0.462	0	1	4428
NHTC	1.998	6.141	0	60.587	4361

Notes. The data is taken from USAID Demographic Health Surveys at the community level. The values are rounded upto three decimal places.

The dependent variable in our research model, i.e., Women's Attitude Towards Violence (ATVF) at the community level, is measured using women's responses to the questions related to her attitude on whether a husband is justified in hitting/beating his wife if - (i) she goes out without telling him, (ii) neglects children, (iii) argues with his husband, (iv) refuses to have sex, and (v) burns the food. The Women's Mobile Phone Inclusion, i.e., the independent variable in our research model, is operationalized using Women's Mobile Phone Ownership (MPOF) at the community level. It denotes the proportion of women having a mobile phone in a community. Additionally, we have considered three categories of control variables based on existing literature [16]. Firstly, we have controlled for demographic level variables using - (i) average household size, (ii) proportion of females employed, and (iii) average education years of women in a community. Secondly, we have controlled for economic well-being using - nightlights for that community as a proxy for economic prosperity and region type. Lastly, we have controlled for the adoption of other media technologies using - the proportion of households with radio and television. Table 1 provides the descriptive statistics for the variables used in the study.

3.2 Methodology

We estimate the effect of women's mobile phone ownership on their attitude towards IPV (Eq. 1) using ordinary least squares (OLS) regression on our cross-section dataset [2]. The subscript i denotes a community, j denotes the country

where community i is situated, and t denotes the year (2015/2016) in which i community is surveyed. The dependent variable is the proportion of women who think wife beating is justified in any of the aforementioned cases in the community i and country j (denoted by $ATVF_{ij}$). Our primary independent variable is the proportion of women having a mobile phone in the community i and country j (denoted by $MPOF_{ij}$). The variable $\mathbf{Z}$ is a vector containing all the control variables mentioned in the previous subsection. ν_j and δ_t are the country and time fixed effect. We assume ε_{ij} to be identically and independently distributed across samples $\varepsilon_{ij} \sim N(0, \sigma^2)$. The coefficient β_1 is of primary interest to our analysis.

$$ATVF_{ij} = \beta_0 + \beta_1 MPOF_{ij} + \gamma \mathbf{Z} + \nu_j + \delta_t + \varepsilon_{ij} \tag{1}$$

There are several sources of potential endogeneity in the relationship between women's mobile phone ownership and their attitude towards IPV that may cause bias in our estimates. Firstly, various omitted variables (observed and unobserved) may bias our estimates. Secondly, it might be possible that communities having women with less tolerant attitude towards IPV is more likely to adopt mobile phones (i.e., reverse causality). We have employed an Instrumental Variable (IV) estimation strategy to deal with potential endogeneity. We have used the log of lightning strikes at community-level using a high-resolution full climatology (HRFC) dataset, which contains information on total lightning flash rates seen by the space-borne optical transient detector (OTD) and lightning imaging sensor (LIS) [9]. Lightning strikes are likely to be correlated with mobile phone ownership because mobile phone adoption is likely to be slower in areas where the antennas are damaged (weaker connectivity) due to more frequent lightning strikes. Secondly, average lightning strikes possibly do not shape women's attitudes towards IPV, and the only way they can affect women's attitudes is by changing women's interaction with mobile phone technology. Therefore, based on the above discussion, our variable satisfies all the conditions required to qualify as a valid instrument [2]. The following section presents the results from empirical analysis and discusses the findings.

4 Results and Discussion

Table 2 summarizes the results from OLS and IV estimations. We have tested for the presence of multicollinearity using the Variance Inflation Factor, suggesting the absence of multicollinearity [2]. In the first model, we estimated Eq. 1 using OLS without control variables and without fixed effects. In the second model, we estimated Eq. 1 using OLS with control variables but without fixed effects. In the third model, we estimated Eq. 1 using OLS, incorporating all controls and year- and country-fixed effects. Lastly, we have estimated the third model using IV estimation.

The primary coefficient of interest β_1 is significant across all models and estimation strategies. For IV estimation, the value of the Kleibergen-Paap rk Wald F statistic (First-stage F-statistic) turned out to be 28.483, which is greater

than the Stock-Yogo critical value of 16.38 at 10% inference bias. This means that our instrument variables are significantly relevant. However, Wooldridge's robust score test statistic was 2.324, with p-value = 0.129, which means we failed to reject the null hypothesis; both OLS and IV estimates are consistent. One potential reason could be larger standard errors in IV estimates, leading to a statistical test lacking sufficient power to reject the null hypothesis of identical OLS and IV estimates. However, the endogeneity concerns we discussed in the previous subsection are plausible. Therefore, we prefer consistent IV estimates over OLS. We found a significant effect of $MPOF_i$ on $ATVF_{ijt}$ with (standard notations used), $\beta_1 = -0.847$, z = -1.75, p-value = 0.080. This coefficient β_1 can be interpreted as, "with a 10% increase in women having a mobile phone in a community, there is on an average 8.4% points decrease intolerant women's attitude towards IPV". In our sample, the ATVF for the average community is 41.54%, resulting in an estimated change of 20.54%. This estimate is quite significant given the fact that ATVF decreased 29.2% over the last five years (2016–2021) in India. In comparison, our mobile phone estimates are nearly four times higher than those for newspapers in Uthman et al. [16], emphasizing the substantial impact of mobile technology over traditional print media in the existing literature. Our instrument variable, the log of lightning strikes, turned out to be significant. The year and country dummies also turned out to be

Table 2. Summary of Ordinary Least Squares Regression analysis between Women's mobile-phone onwership and their Attitude towards violence.

	Dependent Variable: ATVF			
	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)
Independent Variable				
MPOF	−0.2308***	0.1303**	−0.0827***	−0.8476*
	(0.0729)	(0.0595)	(0.0278)	(0.4835)
First-stage				
Log(Flash Rate)				−.0407***
				(0.0076)
Observations	4,428	4360	4360	4360
Controls	No	Yes	Yes	Yes
Country FE & Year FE	No	No	Yes	Yes
F-statistic	10.01	27.64	48.84	44.17
First-stage F-statistic				28.4830
Wooldridge F(1,182)				2.32439
R-squared	0.061	0.1388	0.4738	0.2848

Notes. The coefficients are rounded upto four decimal places. Standard errors clustered at the subregion level are shown in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

significant. The results from the cross-country analysis are consistent with our micro-level analysis (shown in Appendix A). Based on the above discussion, we fail to reject the hypothesis formulated in the second section. Therefore, we conclude that the communities with a higher proportion of women's mobile phone inclusion are linked with the less tolerant attitude of women towards IPV.

5 Implications and Future Directions

Our paper contributes to the existing IS literature on ICT4D by demonstrating the vital role of mobile phones in shaping the attitude of women towards IPV by facilitating access to global cultural scripts that promote gender parity and by increasing social interactions among heterogeneous networks. While existing ICT4D research primarily examines how prevalent attitudes influence ICT adoption, our theoretical framework highlights how ICTs can actively shape attitudes by introducing new perspectives through global connectivity in a world society. Thus, our study extends epistemological inquiry within the ICT4D literature by highlighting the crucial role of mobile phones in disseminating cultures based on liberalistic principles among marginalized communities. Furthermore, our findings have implications for policy interventions aimed at reducing gender inequality. Traditional approaches often face challenges due to deeply ingrained attitudes about the roles of women. Our study shed light on the vital role of mobile phones in shaping attitudes that, in turn, can aid policymakers in other empowerment endeavours such as financial inclusion and labour force participation. Nonetheless, it's important to note that these changes in attitudes take time, and our study is limited to offer any insights on the duration required for such shifts, and it may vary across contexts.

There are also some limitations that future studies may try to overcome. Firstly, we chose to examine mobile phone ownership rather than usage due to data unavailability. Usage data can potentially provide valuable insights into preferred applications and media consumption patterns. Future researchers can use advanced datasets to extract important insights. Secondly, we have not explored the externalities of women's mobile phone inclusion on the attitude of other women and men within the same household and other peers outside the household. Third, our study is limited in explaining which type of communities in LMICs will benefit the most from mobile phone inclusion. In other words, from the policymakers' view, what kind of communities will benefit the most from policies that aim to increase mobile phone adoption among women. Future works may explore other types of attitude shifts from ICTs adoption.

6 Conclusion

Our empirical analysis provides micro-level and macro-level evidences on the relationship between women's mobile technology inclusion and their attitude towards IPV. We conceptualize the relationship using the TCA, WST, and IT Affordances Theory. These findings highlight the significance of mobile phone

technology in instantiating new schemas through the diffusion of global cultural scripts promoting gender parity. Our research extends epistemological inquiry within the realm of ICT4D, highlighting the vital role of mobile phones in disseminating cultural scripts. Policymakers can glean insights from our findings on utilizing ICTs to shape prevailing attitudes, thereby addressing the disadvantaged status of women, particularly in LMICs.

A Appendix: Macro-Level Evidence

Data and Methodology. To enhance our analysis and address generalizability concerns, we've complemented the micro-level study with cross-country analysis using World Bank data (2000–2019). Due to data limitations, we have taken total mobile phone penetration (both men and women). Additionally, we have controlled for economic prosperity using GDP per capita, demographics using population density, women empowerment using the gender inequality index, women's political representation at the national level, and their employment status. We estimate the effect of average mobile phone penetration on women's attitudes towards IPV (Eq. 2) using Pooled OLS, Panel Regression with fixed effects, and IV estimation. The subscript i denotes a country, and t indicates the year (2000–2019). Our primary independent variable is the average mobile phone penetration at the country level ($MPOF_{it}$). Lastly, to address the potential concerns related to endogeneity, we have used instrument variable analysis using the variable proportion of the population with access to a mobile network (denoted by PATN) [10].

$$ATVF_{it} = \beta_0 + \beta_1 MPOF_{it} + \gamma \mathbf{Z} + \varepsilon_{it} \tag{2}$$

Results. Table 3 summarizes the OLS and IV Regression results. The first-stage F-statistic (Kleibergen-Paap rk Wald F statistic) - 6.064, exceeds Stock-Yogo critical value at 20% inference bias. Based on the endogeneity test, we have selected consistent IV estimates with $\beta_1 = -0.6733$, z $= -2.13$, p-value $= 0.034$. This coefficient can be interpreted as, *"with 10% increase in total mobile phone penetration in a country there is on an average 6.734% points decrease intolerant women's attitude towards IPV".*

Table 3. Summary of OLS and IV Regression analysis between mobile-phone penetration and their women's attitude towards violence.

	Dependent Variable: ATVF			
	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)
Independent Variable				
MPO	−0.4206***	−0.1125	−0.2051***	−0.6733**
	(0.0975)	(0.1202)	(0.0695)	(0.3168)
First-stage				
PATN				0.2747**
				(0.1115)
Observations	173	121	121	82
Controls	No	Yes	Yes	Yes
Country FE	No	No	Yes	Yes
F-statistic	18.5900	6.390	14.220	13.820
Kleibergen-Paap rk Wald F statistic				6.064
Wooldridge $\chi^2(1, 182)$				4.149
R-squared	0.126	0.399	0.593	0.299

Notes. The coefficients are rounded upto four decimal places. Standard errors clustered at the country level are shown in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Blockchain: A Structural Topic Modelling Approach

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Abstract. The emergence of blockchain technology has garnered significant attention due to its potential to transform various industries. We examined 2360 articles available in Scopus database using structural topic modelling to summarize the academic advancements in the field of blockchain. To effectively organize the literature and identify potential areas for future research, we leveraged Gartner's Datatopia model. The results of the study identify four dimensions in which the field of block chain can evolve which will help practitioners and academicians in understanding the future of blockchain applications.

Keywords: Blockchain · Structural topic modelling · Datatopia · Emerging Technologies · Natural Language Processing (NLP) · Scenario building

1 Introduction

Blockchain technology is a strategic priority for senior executives [1] and is expected to contribute US$1.76 trillion to the global economy by 2030 [2]. Trust issues with current technologies have led developers, practitioners, and leaders to prioritize alternative technologies [3]. The tamperproof nature of blockchain technology provides hope for industry disruption, with the potential to revolutionize how individuals work [4].

The introduction of blockchain technology has revived the online transactions with the application of Bitcoin which is an electronic cash system that operates on a peer-to-peer basis [5]. Blockchain has disrupted industries such as healthcare [6], supply chain [7], and food safety [8], providing users with up-to-date information, creating trust in product quality. Further, blockchain has the potential to prevent contamination of information by creating transparency in transactions [9]. In healthcare, blockchain can help design more efficient and reliable information systems [6], giving patients control over their records, reducing medical errors, and improving disease management.

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Additionally, blockchain is proven tool for E-waste management tracking and monitoring [10].

With growing literature in the field of blockchain adoption, there arises a need to summarize the past findings and identify the scope for future growth [11]. Our research extends previous answers to the call for research on predicting topics that influences adoption and use of blockchain [12]. The study synthesizes academic literature in the field of blockchain and identifies the emerging research questions for future research using Gartner's Datatopia Model.

The research aims to investigate the impact of changing technology and social interactions on the different scenarios in the blockchain technology field. This leads to two pertinent research questions:

RQ1: What are the focus areas in academic literature on block chain?

RQ2: What are the future scenarios that represents growth of block chain?

The study uses machine-learning algorithm based structural topic modeling [13] to achieve the following objectives:

- To examine the underlying semantic structure of academic research by applying structural topic modelling.
- To combine identified topics into the Datatopia model to develop future scenarios for blockchain applications.
- To identify the knowledge gaps and extract future research questions.

This paper is divided into five sections. The Sect. 1 provides a brief introduction and Sect. 2 covers the research methodology. Section 2 elaborates on topic modelling and Sect. 3 presents the results. Finally, the Sect. 4 covers the limitations and future research questions.

2 Methods and Data

The aim of the study is to understand the development in the field of block chain technology and identify scope for emerging research in blockchain. Scopus database was selected for the keyword search due to its comprehensive coverage [14], and superior data management [15]. We use a single database for analysis to avoid the potential human errors associated with combining multiple databases [16]. To capture all published studies on blockchain, a keyword search was conducted for title, abstract, and keyword (Fig. 1). Search keyword "block chain" or "blockchain" or "block-chain" was used to derive data of title, abstract, and keywords resulting in 44,13 articles. The search was limited to subject area of business management and english language resulting in 2,360 articles. The articles were analyzed using structural topic modelling (STM).

STM is a technique based on semantic associations that identifies latent topics within a document corpus [17]. STM has been used to identify topics in open-ended survey responses, aviation incident reports, hotel reviews, airline reviews, restaurant reviews, hospitality literature, and employees' online reviews [17–23]. We used "search K" to identify the optimum number of topics [24]. Based on the maximum averaged held-out likelihood, 15 semantically descriptive topics were extracted from the corpus (Fig. 2). Semantic coherence and exclusivity are two of the most important concepts used in

measuring the quality of topic models [24]. A topic's semantic coherence is defined as the degree of similarity between its top words. In contrast, its exclusivity is defined as the degree of difference between the top words and those in other topics. The average semantic coherence and exclusivity scores for all topics range from 9.24 to 9.98 and the average semantic coherence ranges from −210.35 to −54.70. Each topic was given a name as per the words appearing in High probability and FREX.

Database: Scopus
Search Date: 10 June 2023
Search keywords: "blockchain" OR "block-chain" OR "block chain"
No. of articles retrieved=44,130

Filter Criteria: Title, abstract, keywords, subject area – business management, language – English, type – article
No. of articles retrieved =2360

Analysis Technique: Structural topic modelling

Fig. 1. Data retrieval process

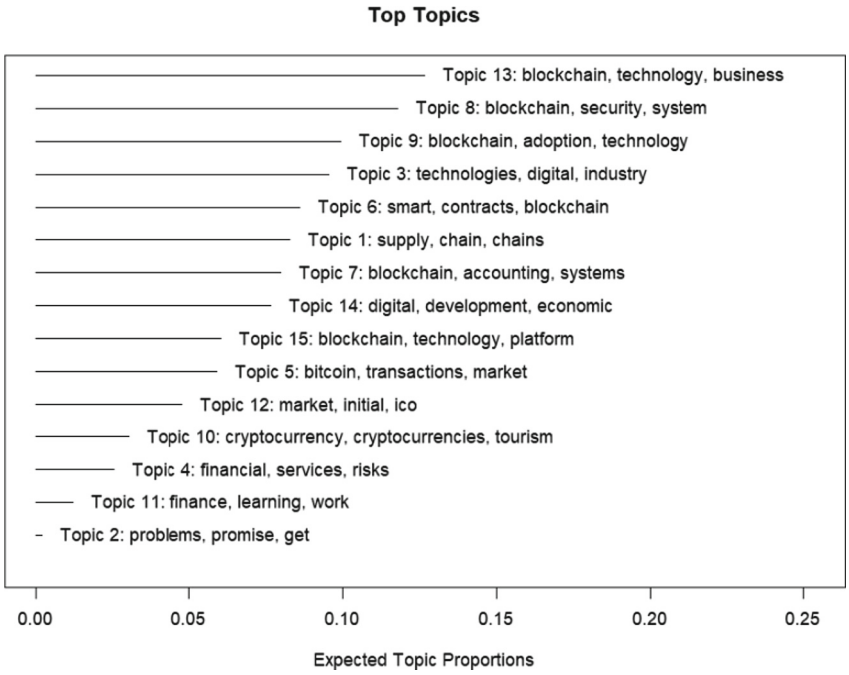

Fig. 2. Extracted topic labels and proportions

3 Results

We identified 15 topics from 2,360 articles derived from Scopus database using STM. The identified 15 topics were grouped using hierarchical cluster dendrogram based on their distance (Fig. 3). Four clear clusters were seen: Cluster 1 (comprising of topic 12, 10, 4, 11), Cluster 2 (comprising of topic 5, 6, 8), Cluster (comprising of topic 14, 3, 7, 13), Cluster (comprising of topic 9, 1, 15) while Topic 2 was reflected as a separate branch overlapping all the four clusters.

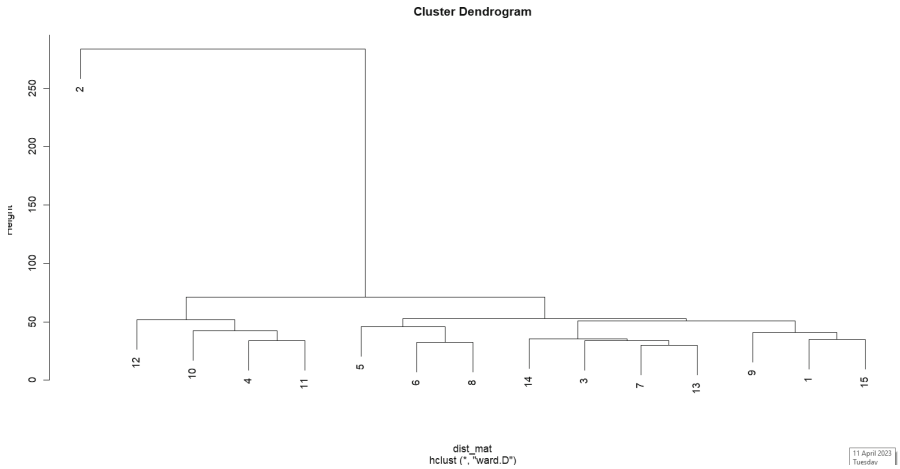

Fig. 3. Dendogram

The four clusters were assigned to relevant quadrants in Gartner's Datatopia model [25] to understand the future scenarios for blockchain. According to Gartner Datatopia model, in future the society will either be connected or conflicted and the technology will either be in control or amok (Fig. 4). The combination leads to generation of four possible scenarios as discussed in subsequent sections.

3.1 Scenario 1: Society, Inc. - "Whatever" (Control-Conflicted)

First scenario, Society "Whatever" represents state where technology is controlled by the society and goals are conflicting. This quadrant represents higher usage of blockchain. It comprises of four topics- Topic 12 (Initial coin offering), Topic 10 (Payments using crypto), Topic 4 (BFSI), Topic 11 (Cyber security). Application of blockchain for Initial Coin Offerings (ICOs) allows corporations and governments to control, authenticate, and enforce their fundraising rights, influencing society. Further, blockchain technology is redefining the future of work by enabling new ways to perform transactions, mainly through cryptocurrencies. Additionally, within the banking, finance, and insurance blockchain is used to manage data securely and efficiently. Blockchain can provide improved security measures, allowing entities to maintain control and stability within their systems.

3.2 Scenario 2: Datatopia "Aspiring Creativity" (Control-Connected)

The second scenario, Datatopia "Aspiring Creativity" represents state where the technology is under control, society is connected and the goals are aligned. This quadrant focuses on the innovative use of blockchain technology. It comprises of three topics: Topic 5 (Transaction and mining), Topic 6 (Smart Contracts), Topic 8 (Data Privacy). Blockchain is redefining the method of financial transactions and mining procedures, moving towards a more connected world. The use of smart contracts is a revolutionary blockchain application automating contractual obligations and facilitating secure, transparent transactions. Thus, blockchain can enhance data privacy, improving control and trust within digital ecosystems.

3.3 Scenario 3: Digital Wild West "State of the Nature" (Amok-Conflicted)

Third scenario Digital Wild West "State of Nature" represents a state where the technology is amok, the society and goals are conflicting. When technology runs amok, society does nothing but respond. This quadrant elaborates on the use of technology as a means of self-protection. It comprises of four topics: Topic 14 (International law and economy), Topic 3 (Emerging sustainable technology), Topic 7 (Accounting and audit), Topic 13 (Governance). The application of blockchain within international law and economy provides an alternative legal and economic systems. Blockchain can evolve the sustainable technologies and create new societal opportunities and challenges. Blockchain technology's application in accounting and auditing can significantly improve efficiency and accuracy. Finally, incorporating blockchain leads to good governance.

3.4 Scenario 4: Sorcerer's Apprentice "Ruled by Machines": Amok-Connected

Fourth scenario, Sorcerer's Apprentice "Ruled by Machines" presents a state where the technology is amok, society is connected and goals are aligned It depicts a future where blockchain technology is integral to societal structures. It comprises of three topics: Topic 9 (Adoption of Blockchain), Topic 1 (Supply chain and technology), Topic 15 (Challenges in adoption). A section of literature focusses on adoption of blockchain technology and its applications in various sectors and driving societal transformations. Blockchain can significantly enhance the transparency, efficiency, and traceability of supply chain systems. Despite its potential, several challenges persist in adopting blockchain technology, affecting the pace and direction of its influence.

3.5 Overarching Topic

Topic 2 (Blockchain technology for enhancing IoT security) was present across all four quadrants due. A fundamental security requirement is represented by this topic, which is important in any future scenario depicted, whether it is a controlled, conflicted, or optimized scenario.

	Conflicted (In the conflicted world, technologies are often used to block other technologies. Goals are conflicting)	**Connected** (In the connected world, all kinds of technologies interact with each other. Goals are aligned.)
Control (In the controlled world we know what we want technology to do, and make it so)	**Scenario 1: Society, Inc. "Whatever"** Topic 12 (Initial coin offering) Topic 10 (Payments using crypto) Topic 4 (BFSI) Topic 11 (Cyber security)	**Scenario 2: Datatopia "Aspiring Creativity"** Topic 5 (Transaction and mining) Topic 6 (Smart Contracts) Topic 8 (Data Privacy)
Amok (When technology runs amok, society does nothing but respond)	**Scenario 3: Digital Wild West "State of the Nature"** Topic 14 (International law and economy) Topic 3 (Emerging sustainable technology) Topic 7 (Accounting and audit) Topic 13 (Governance)	**Scenario 4: Sorcerer's Apprentice "Ruled by Machines"** Topic 9 (Adoption of Blockchain) Topic 1 (Supply chain and technology) Topic 15 (Challenges in adoption)

Fig. 4. Datatopia Model

4 Discussion and Future Implications

The analysis of 2360 articles from the scopus database using STM and Datatopia Model [25] revealed upcoming trends in the blockchain technology field. The STM analysis distinguished 15 distinct topics, covering a wide range of areas, including blockchain's involvement in intellectual property, privacy protection, the changing work landscape, and its potential impact on global issues like climate change. The Datatopia model aided in organizing these blockchain topics into larger societal contexts, including Conflicted, Connected, Control, and Amok. While some topics, such as the future of work, were recognized as means for data-driven societal control, others, such as internet evolution, signified the transformative potential of blockchain. However, the study also identified significant gaps that necessitate further investigation. These gaps include the environmental and sustainability effects of blockchain, the ethical consequences of its use, challenges in widespread adoption, potential risks in certain industries like travel, and its overall role in strengthening IoT security.

Considering Gartner's Datatopia model, the study synthesized academic landscape and potential research questions. Future research should explore the various aspects of blockchain technology, including how it may promote sustainability within supply chains, mitigate risks and challenges in multiple domains, and ensure a safe and efficient implementation process in industries such as freight transportation. Additionally, researchers should examine the negative aspects of blockchain technology, including its implications on energy consumption, scalability, and privacy concerns in manufacturing, auditing, and accountability practices for non-governmental organizations. As well as investigating the potential threat to cryptocurrencies in the travel and tourism industry, they should investigate the implications of blockchain technology for personalized medical services, IoT devices, and SME adoption.

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Portfolio Selection Using Network Filtering Methods: A Graph Theoretic Approach

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Abstract. The study presents a case of portfolio selection, allocation, and optimization using network-based methods. The study data consisted of selected stocks from Indian equity market. The computational analysis performed explores the use of networks science methods such as MST, Threshold filtering, centrality analysis, and disparity filtering. The portfolio selected based on these methods are further constructed, optimized and the evaluated using series of metrics such as reliability of portfolio, realized risk, and degree of reduction in the effective portfolio dimension. This study thus gives a mix of strategies that can be effectively used for portfolio selections and for construction of systemic-risk tolerant portfolios.

Keywords: Portfolio section · Network Science · Financial Networks · Econophysics

1 Introduction

The portfolio analysis uses micro and macro factors which can influence the sentiments of the stocks. With this research we are proposing network analytics for the portfolio analysis. Portfolio theory pioneer Markowitz set the groundwork for Markowitz optimization procedure. In Markowitz portfolio optimization the focus is on building a varied asset portfolio, which is essential in financial management to balance risk and reward. The Markowitz model is built on a series of assumptions concerning the behavioural qualities of investors participating in the markets and the price returns of the assets in those markets [1, 2]. It is well recognized that for obtaining the suitable weights through implementation of Markowitz/Sharpe optimization, the underlying assumptions and data pre-requisites should be met. The weights are very sensitive to the underlying assumptions and data pre-requisites. The series of assumptions and data pre-requisites of Markowitz's optimization method are hardly witnessed in practical scenarios. To begin with, the returns of assets are considered to be Gaussian variables, although, in real financial data series, price return distribution has fat tails. Next, it is assumed in the Markowitz optimization model that the parameters utilized in the model (i.e. the mean values and the covariance matrix) are constant. Lastly, even though these parameters are

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actually unchanged in the time horizon applicable for the problem, the statistical estimation of these parameters over fixed time intervals T would lead to a problem referred to as 'curse of dimensionality'. As the covariance matrix consists of N (N − 1)/2 − N2/2 individual items, however, the quantity of records utilized in the estimation is NT. For this case, a time series of length T >> N is needed so as to have minimal errors in the estimation of covariances. However, in situations where the length of T is excessively long the non-stationarity in data series turns out to be increasingly important [3]. Therefore, it is critical to identify and use methods which are competent to perform filtering of the part of the covariance matrix which would be less inclined to be influenced by statistical uncertainty. Furthermore, the filtered information can be possibly employed in portfolio selection and portfolio construction tasks. The use of different network filtering methods such as MST, Random Matrix Theory, and hierarchical clustering (both single and average linkage), filtered networks can be obtained which can be further used for portfolio selection [3–6]. The extant literature has empirically proven that the filtered networks obtained from these network pruning methods are statistically reliable and are robust enough to accommodate both non-stationarity and fat tail distribution in time series data of equity markets.

The current study employs a series of network-based methods and measures in a portfolio management problem involving portfolio selection, construction and evaluation. For this purpose, the data series of 335 stocks belonging to Indian stock market is made use of. The present paper is organized as follows. The current section presents the introduction. The Sect. 2 presents the context of the study an describes the Methods, which presents the data and computational methodology employed in this paper. In Sect. 3, presents the findings which elaborates the computation of returns for holding and realization period, MST construction, details the weighted network modelling along with network filtering, explains the portfolio construction for investment and realization periods, presents the comparative analysis of the effectiveness of different network methods. Sect. 4 discussed the paper and Sect. 5 concludes the paper.

2 Research Methods

2.1 Data Description

The 335 stocks used in the Indian market network analysis are employed here for portfolio construction purpose. The duration of the portfolio analysis study ranges between 3rd January 2011 and 31st December 2014. The historical closing prices of the 335 stocks are retrieved for this particular duration. The study period is sub-divided into two segments, holding period (3rd January 2011 to 31st December 2012) and realization period (1st January 2013 to 31st December 2014).

2.2 Computational Analysis

The analytical workflow of the paper is illustrated in Fig. 1. The workflow follows two distinct paths. In the first path, the two years data of the holding period is utilized for implementing network filtering methods. Minimum Spanning Tree and weighted network models are constructed from this data series of 335 stocks. The stocks belonging

to the tangling ends of the MST are identified. A centrality analysis is performed once the weighted networks are generated, and subsequently, the peripheral set of stocks is identified. The backbone structure of the weighted network is extracted using global threshold filtering and disparity filtering methods, and then the disjointed sets of stocks are identified. The selected stocks from MST, centrality analysis, global threshold filtering, and disparity filtering analysis are further used for portfolio construction and portfolio optimization using Markowitz/Sharpe models. In the second analytical path, the weights of the optimized portfolios from all the four techniques (obtained from the first path of analysis) are retrieved and are further used for portfolio construction using the data series of realization period. A comparative analysis is performed between portfolios of the holding period and the realization period for each of the four network techniques. The computational methodology and the findings obtained from the two paths of analysis are explained in the next sections.

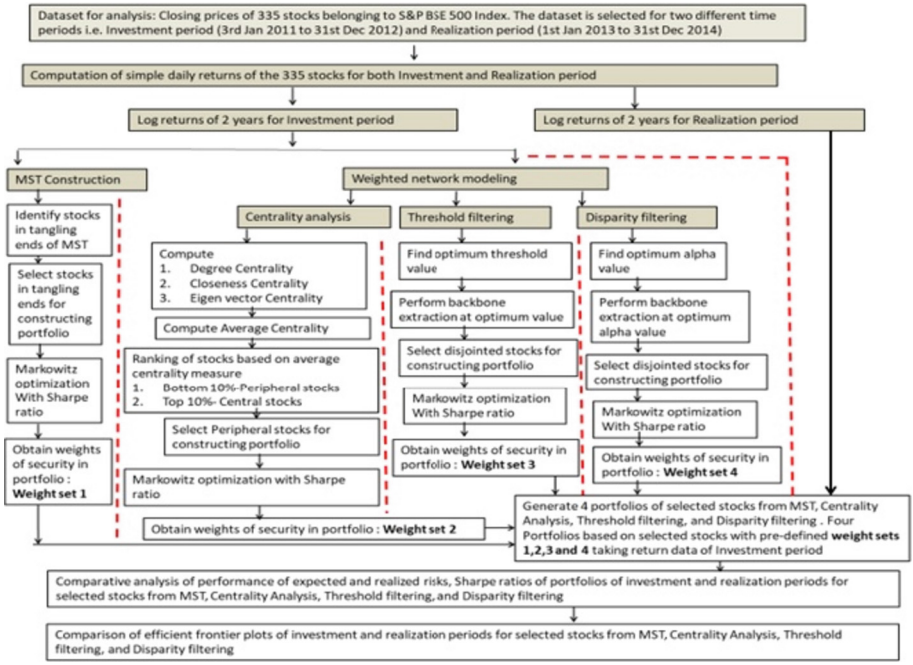

Fig. 1. Research workflow

Computation of Returns for Holding and Realization Periods

The arithmetic returns of the 335 stock prices are computing using the equation

$$S_i^{ar} = \left(\frac{CP_t^{ind} - CP_{t-1}^{ind}}{CP_{t-1}^{ind}} \right) \tag{1}$$

For each of the 335 stocks, there are 494 returns dataset for the holding period and 491 datasets for the realization period.

2.3 Construction of MST

For constructing the MST, the cross-correlation coefficients are first computed using the equation,

$$P_{i,j}^{ar} = \frac{\left\langle S_i^{ar} S_j^{ar} \right\rangle - \left\langle S_i^{ar} \right\rangle \left\langle S_j^{ar} \right\rangle}{\left(\left\langle S_i^{ar^2} \right\rangle - \left\langle S_i^{ar} \right\rangle^2 \right) \left(\left\langle S_j^{ar^2} \right\rangle - \left\langle S_j^{ar} \right\rangle^2 \right)} \tag{2}$$

where, $S_i^{ar}$and S_j^{ar} refers to the arithmetic returns of stock i and j. Next, the distance measure was computed using the equation,

$$d_{i,j}^{ar} = \sqrt{2\left(1 - p_{i,j}^{ar}\right)} \; 0 \leq d_{i,j}^{ar} \leq 2 \tag{3}$$

The MST is next constructed using Prim's algorithm [7]. The MST is visualized, and the stocks at the tangling ends of the MST plot were identified. The tangling ends refer to the vertices in the MST diagram which doesn't have any forward linkages. In other words, the nodes excluding the connectivity nodes, hub nodes and central nodes are referred to as tangling nodes.

The MST obtained from the holding period data, in which 146 stocks representing the entire set of tangling ends in the MST plot were selected. Being the tangling ends of the MST, these stocks would be highly diversified as any information would take much longer to reach these tangling end points. The stocks being very distant from each other are possibly really dissimilar among themselves in term of the collective price fluctuations. Thus, they would be good candidates for a well-diversified portfolio.

The list of 146 stocks selected from MST method and these 146 stocks were next used to construct a portfolio using Markowitz/Sharpe optimization models. The weights obtained from the Markowitz/Sharpe optimization models were retrieved and were further used for the construction of portfolios in the realization period. The efficient frontier plot was also plotted for portfolios in the holding and realization periods.

2.4 Construction of Weighted Network Model for Holding Period Data

For the construction of the weighted network for the holding period data, the residual returns were first computed. Next, the weights of the edges were computed. Using the weighted correlation coefficient matrix, an undirected weighted network was constructed for holding period's stock price datasets. The *i* graph package in R was employed for this purpose [8]. The mean of $w_{i,j}$ from daily time series data is not time variant over the years. Thereby, the weighted matrices with $w_{i,j}$ entries are more reliable for Markowitz optimization tasks. Thus, weighted matrices with $w_{i,j}$ entries are a better choice in comparison to simple correlation matrices, whose means are time variant in nature.

3 Findings

3.1 Centrality Analysis of Weighted Network

Three centrality measures are next computed for each of the stocks in the weighted network belonging to the holding period. The centrality measures that were computed consist of degree centrality, closeness centrality and eigenvector centrality. An average centrality measure consisting of the weighted arithmetic mean of all the three centrality measures is next computed. The stocks are then ranked based on their average centrality scores. Research has illustrated the selection of central and peripheral securities based on centrality scores [9]. The current analysis adopts a similar strategy. According to this strategy, the top 10% of stocks were selected as "central stocks" and the bottom 10% were selected as "peripheral stocks".

The set of stocks selected as peripherals are the ones which are of interest for portfolio diversification, as these are located peripherally in the network and would be very distant from each other. These would make them possibly indeed diversified among themselves in terms of collective price movements. They would, therefore, be worthy selections for a well-diversified portfolio. Table 1 exhibits the 34 stocks selected based on the bottom 10% in the average centrality rankings. The set of these 34 peripheral stocks were used to construct a portfolio using Markowitz/ Sharpe optimization model. The weights (w_i^s) obtained from the Markowitz/Sharpe optimization model in holding period were retrieved and were further used for the construction of portfolios in the realization period. The efficient frontier plots were also plotted for portfolios in the holding and realization periods.

3.2 Network Filtering of Weighted Networks

In this phase of the analysis, two weighted network filtering methods namely, global threshold filtering and disparity filtering are used to retrieve the backbone structure of the equity network. The network filtering step is performed on the equity network derived using the holding period data. The backbones structures obtained from both methods are visualized, and disjointed set of stocks are identified.

Global Threshold Filtering. For performing the global threshold filtering, the optimum threshold value is found by inflection method. The optimum threshold value is obtained to be 0.22928. The complete weighted network is filtered using the optimum value. The backbone structure of the weighted network obtained after threshold filtering is exhibited in Fig. 3.

The stocks which do not possess any linkage in the backbone structure are retrieved. The stocks being disjointed are possibly really diversified among themselves and would be good candidates for a well-diversified portfolio. There were 24 stocks which were selected based on their disjointed status in the filtered network. The list of 24 stocks selected from threshold filtering method and the set of these 24 stocks were used to construct a portfolio using Markowitz/Sharpe optimization model. The weights (w_i^s) obtained from the optimization models of the holding period data were retrieved. These weights were further used for the construction of portfolios in the realization period.

Table 1. List of peripheral stocks figuring in the average centrality rankings

S. No.	Stock name	S. No.	Stock name
1	Apollo Hospitals Enterprise Ltd.	18	Aurobindo Pharma Ltd.
2	Balkrishna Industries Ltd.	19	Bharat Heavy Electricals Ltd.
3	Carborundum Universal Ltd.	20	Castex Technologies Ltd.
4	CMC Ltd.	21	Crisil Ltd.
5	GlaxoSmithKline Pharmaceuticals Ltd.	22	Godrej Consumer Products Ltd.
6	Greenply Industries Ltd.	23	Hatsun Agro Products Ltd.
7	HDFC Bank Ltd.	24	Hindustan Unilever Ltd.
8	Hindustan Zinc Ltd.	25	Indraprastha Gas Ltd.
9	Kansai Nerolac Paints Ltd.	26	KPIT Technologies Ltd.
10	Lycos Internet Ltd.	27	Marico Ltd.
11	Monsanto India Ltd.	28	National Aluminium Co Ltd.
12	Oil Natural Gas Corpn Ltd.	29	Rain Industries Ltd.
13	Rallis India Ltd.	30	Sanofi India Ltd.
14	Shriram City Union Finance Ltd.	31	Symphony Ltd.
15	Tata Power Co Ltd.	32	Titan Company Ltd.
16	Torrent Pharmaceuticals Ltd.	33	Unichem Laboratories Ltd.
17	Vakrangee Ltd.	34	VIP Industries Ltd.

The efficient frontier plots were also plotted for portfolios in the holding and realization periods (Fig. 2).

Disparity Filtering. In case of disparity filtering, the first step consisted of obtaining an optimum alpha value for which disparity filtering can be performed. The alpha value should be such that the backbone structure obtained should essentially retain the multi-scalar clustering structure of the original network. For determining the optimum alpha, the following values were taken 0.2, 0.15, 0.10, and 0.05. For each of these alpha-values, the disparity filtering was performed on the weighted network, and subsequently, the backbone structures were extracted. The Barrat weighted clustering coefficients were computed for each of the backbone structure for all the alpha values.

The Barrat weighted clustering coefficients were also computed for the unfiltered weighted network. The weighted clustering coefficients of the backbone structures at different values of alpha were compared with that of the value obtained for the unfiltered weighted network. The optimum alpha-value is the one for which the weighted clustering coefficient is the closest to that of the unfiltered weighted network. The optimum alpha-value was obtained to be 0.1. The disparity filtering was performed using the alpha value of 0.1. The backbone structure extracted after disparity filtering at an alpha value of 0.1 is exhibited in Fig. 4.

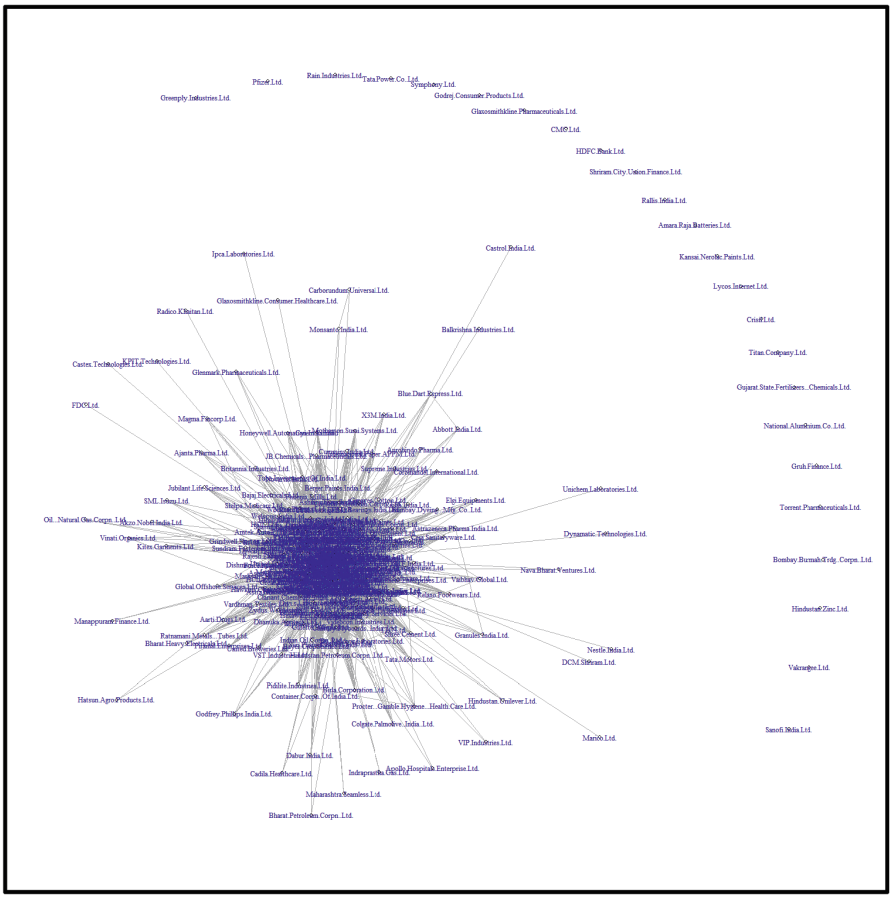

Fig. 2. Backbone structure of weighted network obtained after global threshold filtering.

The backbone structure was visualized, and the stocks which didn't have any connectivity structure in disparity filtering were selected for portfolio construction. The stocks being disjointed to its peers with a statistical significance of 90% are possibly really dissimilar among themselves in terms of collective price fluctuations. Hence, they would be worthy candidates for a well-diversified portfolio. There were 117 stocks which got selected based on their disjointed status in the backbone structure obtained from disparity filtering. The list of 117 stocks selected from disparity filtering method is provided and set of these 117 stocks were used to construct a portfolio using Markowitz/Sharpe optimization model. The holding period data was used for the Markowitz/Sharpe optimization model and the weights (w_i^s) obtained were retrieved. These weights were further used for the construction of portfolios in the realization period. The efficient frontier plot was also plotted for portfolios in the holding and realization periods.

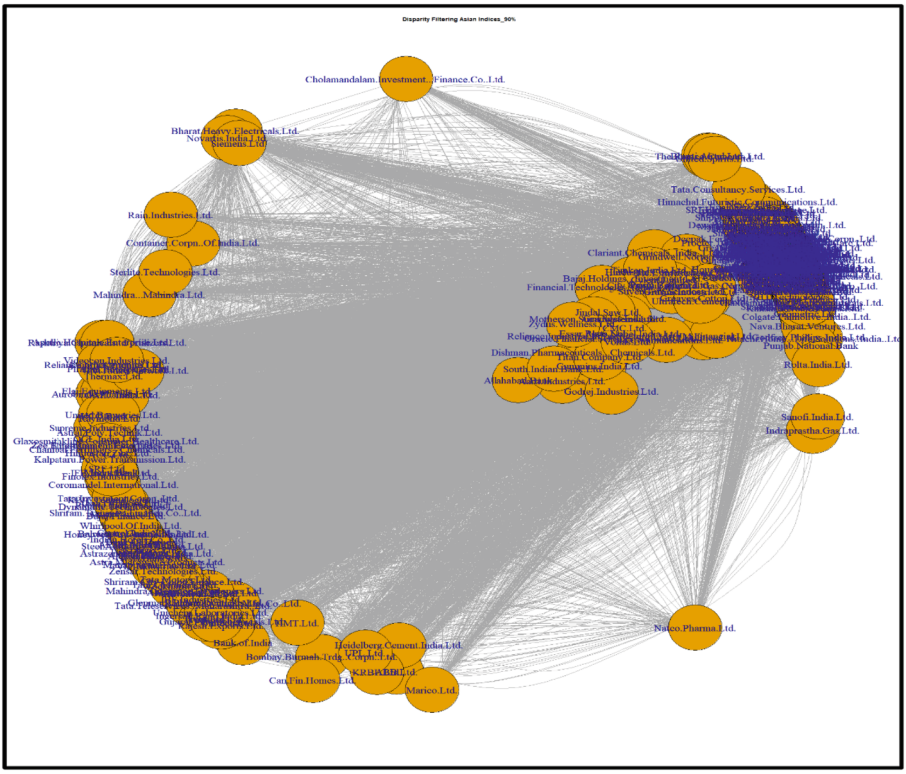

Fig. 3. Backbone structure of weighted network obtained after disparity filtering

3.3 Portfolio Construction for Holding and Realization Periods

The portfolio construction for realization period is performed by taking N_p stocks, with a portfolio horizon of T trading days. The value of N_p varies based on the size of the selected set of stocks from different network-based selection methods discussed in above sections (such as MST, centrality analysis, threshold filtering and disparity filtering). The optimization is supposed to take place at time t_0 using the covariance matrix of the holding period. The covariance matrix of holding period is based on the correlation matrix of T_I days preceding t_0. T_I days is the size of the holding period. In the present analysis, both the periods of portfolio horizon (realization period) and T_I days (holding period) consist of 2 years trading data (T_I is 494 days and T is 491 days). The datasets of T trading days of holding period and N securities were used for the computation of covariance matrices. From the computed covariance matrices, the predicted optimal portfolio at time period t_0 was derived. The returns of each of the stocks and their respective volatilities in the T_I days following t0 were computed. The realized returns and volatilities in the realization period were computed by multiplying with the weights obtained in the Markowitz optimization (with Sharpe ratio) performed at period t_0. For the Markowitz/Sharpe optimization task, the risk-free rate (rf) is taken as 10-year long-term Government of India bond returns.

3.4 Comparative Analysis of the Effectiveness of Different Network Methods

The size of the portfolio N_p is 146, 34, 24 and 117 for the sets of stocks derived using the MST method, centrality analysis, global threshold filtering and disparity filtering methods, respectively. The above procedure of portfolio generation at time t0 and weights multiplication for returns and volatilities in the realization is implemented for each of the selected set of stocks of all the four network-based methods. Based on the portfolio analysis of holding and realization periods, a comparative analysis of the predicted risk-return curves with the realized risk-return curves was performed. For comparing the performance of portfolios derived using each of the network methods, three evaluative measures are made use of. Research study by Tola et al. has given three measures for comparative analysis of the effectiveness of network filtering methods in portfolio selections [3]. The measures are as follows:

Reliability of Portfolio. This measure is computed by dividing the risk difference between expected (σ_p) and realized $(\hat{\sigma}_p)$ with that of realized risk. One can consider a portfolio to be relatively more reliable when the left-hand side of the following equation is a smaller digit [3],

$$\Re = \frac{\sigma_p - \hat{\sigma}_p}{\hat{\sigma}_p} \tag{4}$$

Realized Risk. The second measure of the effectiveness of portfolio is simply the realized risk $\hat{\sigma}_p$. Obviously one can consider a portfolio to be lesser on risk side when it's realized risk is a smaller digit. It is to be noted that on the whole, a portfolio possessing a smaller degree risk is not essentially a better choice than that of a relatively higher risky portfolio. Indeed, if there is a higher degree of uncertainty on the risk value of a safe portfolio, a portfolio investor may encounter higher fluctuations, which would subsequently lead to a larger loss [3].

Degree of Reduction in the Effective Dimension of the Portfolio. The third measure of the effectiveness of portfolio is the "degree of reduction in the effective dimension of the portfolio" [3]. A large portfolio size may be costly to deal with because it would incur higher transaction costs for the investors during the times of portfolio rebalancing. Even though one ignores the issues at times of portfolio rebalancing and benchmarking, it is important to compute the "effective" number of stocks which possesses a substantial investment of money. This measure is computed using the following equation,

$$N^{(eff)} = \frac{1}{\sum_{i=1}^{N} (w_i^s)^2} \tag{5}$$

The value of this measure (N(eff)) is equivalent to 1 in cases wherein the totality of wealth is invested in a single asset. On the other hand, the value of this measure would become N in situations wherein there is an equal division of wealth among all the N assets, i.e. $w_i{}^s = 1/N$. It might be important to note that the measure N(eff) would not lead to the number of assets in cases wherein there are investments made on non-vanishing amount of wealth. This measure merely provides a rough estimation of the total quantity

of assets that can be effectively utilized for construction of a smaller portfolio having its risk returns characteristics not substantially different from the actual portfolio of N assets. Table 2 provides the summary of the comparative analysis of each of the network methods using the three measures.

Table 2. Summary of the network methods effectiveness

Network based portfolio selection method(s)	Reliability of portfolio ($\Re$)	Realized Risk of portfolio $(\hat{\sigma}_p)$	Degree of reduction in the effective dimension of the portfolio $(N^{(eff)})$
MST	0.5764	20.921%	5
Centrality analysis	0.2552	15.214%	7
Threshold filtering	0.1396	17.122%	8
Disparity filtering	0.0595	14.760%	14

From Table 2, it is clear that in case of reliability scores, the deviation of disparity filtering based portfolio's predicted and realized risks is considerably lower than the ones acquired from the other network-based methods. This finding clearly points to the fact that by deploying disparity filtering methods for portfolio construction one can obtain a more reliable portfolio (with regard to the error in the predicted risk) than the ones derived using methods like MST, global threshold filtering and centrality analysis.

The realized risks of the portfolios derived using the four methods, i.e. MST, global threshold filtering, disparity filtering and centrality analysis are next compared. The realized risk is a quantification of the level of riskiness associated with the constructed portfolio. From Table 2, it is noted that for this data series, the disparity filtered based portfolio's realized risk is smaller than the ones acquired from the other methods. On examining the riskiness (i.e., the realized risk) of the portfolio constructed using MST method, it is clearly evident that such portfolios have higher concentration of systematic risk in comparison to portfolios obtained from other methods.

The portfolio's effective size N(eff) is found for each of the four methods, and is further compared. From Table 2, it can be inferred that the portfolios built with MST have a relatively lesser value of effective dimensionality. This indicates that the maintenance costs of such portfolios are smaller than ones built using disparity filtering approach. The portfolios built using disparity filtering for this set of data series has the highest effective dimensionality. This means that for disparity filtering based portfolios the maintenance cost would be the highest among all the studied methods.

The efficient frontier plots of investment and realized periods are also compared for each of the network methods. The efficient frontier is the curve plotted on XY axis (risk-return framework) that depicts the entire set of efficient portfolios. An efficient portfolio is expressed as the portfolio that would maximize the expected value of return for a certain level of risk (standard deviation), or the portfolio that would minimize the risk subjected to a given value of expected return. So, to calculate the efficient frontier, one has to perform the minimization of the risk (standard deviation) given some value of

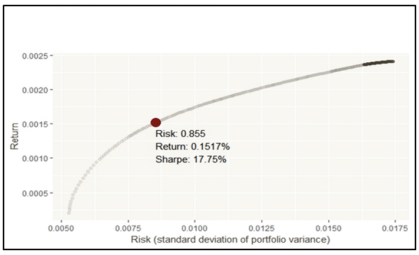

Fig. 4. Efficient frontier of the portfolio using disparity filtering for holding period

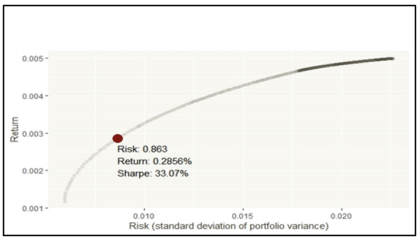

Fig. 5. Efficient frontier of the portfolio using disparity filtering for realization period

the expected return. From the comparative analysis of all the efficient frontiers of each of the network based methods, it was found that the frontier belonging to disparity filtering based portfolio selection was the closest amongst all the studied methods. Fig(s) 4 and 5 exhibit the efficient frontier plots of disparity filtered based method for both investment and realization periods.

4 Discussion

In this paper, the objective was to utilize the different network methods for portfolio selection, portfolio construction, and portfolio evaluation. The computational analysis performed in the paper explores the use of networks for portfolio creation by demonstrating the use of different genres of network methods in portfolio selection exercises and evaluating the outcomes of the portfolio optimization models. The computational analyses performed regarding the alternative investment strategies that network-based methods can offer in order to reduce the impact of systemic risk attacks in market stress conditions. This paper demonstrated how network-based filtering methods can be employed to select a set of securities which would be less likely to be impacted during market stress conditions. For example, incorporating securities positioned at the tangling ends of the MST in a portfolio would make it highly tolerant towards systemic risk attacks. Similarly, incorporating peripheral stocks (based on centrality scores) in the portfolio would do the same purpose. Likewise, choosing securities positioned in disjointed statuses in backbone structure (obtained from either threshold filtering or disparity filtering) and incorporating them in the portfolio would perform the similar purpose. The second question that was addressed in this paper was about the way an investor can build a robust portfolio from correlation matrices data possessing significant noise content. The earlier research have demonstrated that the correlations matrices estimated from financial time series (recorded from empirical data) possess such high levels of noise that their interdependency structures can, in effect, be considered as random [10]. Also, the earlier work has contended that filtered correlation matrices are more stable and the difference between estimated and realized risk-return values of such matrices is very minimal and are relatively lower than that of original unfiltered empirical matrices [11]. This study has demonstrated the approach a potential investor should undertake in scenarios wherein high noise content exists in empirical correlation matrices.

The study results is marked by specific strengths and limitations. Strictly speaking, for a fixed quantity of N and T, the best suited filtered correlation coefficient matrix can vary depending on the strongest constraint a portfolio investor perceives within the three evaluative measures, i.e., the riskiness of the portfolio, the estimation's reliability, and the effective size of the portfolio. This study gives a mix of strategies that can be effectively used for portfolio selections and for construction of systemic-risk tolerant portfolios. One of the limitations of the study is that the asset selection has only been done based network-based methods and other conventional methods for asset selectin has not been employed here. The network selection and optimization method has been tested in Indian market in this study. Future researchers can experiment with the same method in other markets and validate its performance and generalizability.

5 Conclusion

The paper presented a portfolio optimization case which exemplifies the use of network-based methods in the selection of securities for the construction of an optimum portfolio. The study utilized the network-based methods for examining the cross-security dependency structures of selected Indian equity market stocks. Using the findings of the cross-security linkage analysis and strategizes the portfolio selection process. Each of the different network-based methods used in this paper provides distinctive sets of portfolio optimization results.

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Exploring the Fusion of Metaverse and Sports: Current Trends and Future Directions

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Abstract. Metaverse is a virtual realization of the physical environment made possible with lifelogging tools like physiological sensors that help in performing life-like virtual interactions amongst users/customers present as avatars in the cyber-physical world. The metaverse is a rapidly growing technology that has the potential to revolutionize the world of sports. In this research work, we used the Scopus database to extract documents published in the domain of sports and metaverse. The descriptive analysis and collaboration analysis of existing literature, and topic modeling Latent Dirichlet Allocation of abstracts highlight the use of augmented reality, virtual reality, blockchain, artificial intelligence, wearables, and the Internet of Things in building domain-specific applications. The findings reveal that these technologies can enhance the learning and training experience for athletes, providing them with immersive and interactive environments to hone their skills. The physical and psychological well-being of athletes can be ensured with the rational use of metaverse. However, the use of these technologies also raises concerns about privacy and the protection of data. The research in the domain of information technology and information systems from marketing is also unexplored. As the metaverse continues to evolve, it is important for the sports industry to address these concerns and ensure that the use of these technologies is done in a responsible and ethical manner.

Keywords: sports · metaverse · augmented reality · virtual reality · healthcare · e-sports · digital technologies

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1 Introduction

The term "metaverse" refers to a 3D virtual environment that emulates facets of the real world and enables users to interact and communicate in the digital space. It is a collection of 3D virtual environments designed for boosting social and business-related interactions. Metaverse is a highly focused area in industrial innovations due to the rapid growth of blockchain, artificial intelligence, and extended reality (augmented reality (AR) and virtual reality (VR)) in the areas of education, health management, tourism management, order tracking, supply chain management, and more (Dwivedi et al. 2022; Dwivedi et al. 2023; Kar and Varsha 2023).

The Covid-19 pandemic transformed the low acceptance of technology and forced people to increase immersive time, that is, perform personal and professional tasks through virtual modes such as meetings or monetary transactions (Mehra et al. 2023; Mogaji et al. 2023). Increased acceptance of virtual technologies encouraged brands to rapidly move toward Metaverse - the 3D immersive virtual spaces where blockchain-enabled non-fungible tokens (NFTs) can provide a new hybrid experience to users (Arya et al. 2023).

The social media revolutionized sports consumption and participation, by allowing fans and spectators to present views and opinions in real-time. Sports organizations, sports marketers, teams, sports managers, athletes, brand managers, and many more entities utilized social media to target global audiences which was earlier not possible through conventional sports consumption platforms such as television (Mehra et al. 2022). Metaverse holds the potential to reshape sports altogether. Right from the domain of physical and psychological health management of athletes, sports education, physical education, participation, and consumption of sports can be rejigged making sports a lot more cohesive for fans and athletes (Demir et al. 2022). For health and fitness management among athletes, metaverse has opened new doors. Performance enhancement and mental health management of e-sports athletes are the two primary areas where metaverse applications need to be properly thought and implemented (Cai et al. 2022).

With numerous positives, the researchers have presented concerns over the use of Metaverse as well. In the domain of marketing, AR/VR can provide never-seen-before enriching experiences to customers (Dwivedi et al. 2023a). One thing that researchers are deeply concerned about is the privacy of the personal data that contains the micro-information related to the participants such as personal information, digital signatures, and interaction patterns. Security of supply chain data (Richey Jr et al. 2023), implementation of Digital Twins, and logistics are some of the issues that need to be addressed at the managerial levels (Dwivedi et al. 2023b). Environmental sustainability is another major cause of concern as metaverse platforms require an immense amount of energy to be kept operational (Kshetri and Dwivedi 2023).

The primary goal of the semi-systematic review of the literature is to explore the utility, applications, and adoption of metaverse or AR/VR across different fields of sports. The findings in this study primarily reveal the use of AR and VR across the domains of sports education, physical education, e-sports, sports psychology, behavior analysis, and more. The findings in this research are novel as we did not come across any study that has examined the use of metaverse or AR/VR technologies in sports at a broader scale. Latter discussion encourages us to find the answer to the following research question:

(RQ: What are the prominent themes of research in the domain of sports and metaverse?).

2 Methodology

For performing the semi-systematic review of existing literature, we used the Scopus database, as it is one of the largest databases of scholarly articles and research. The research that contains a combination of keywords as per the following query was searched. AND/OR boolean operators help to remain specific with the topic of research and avoid unwanted articles.

(("metaverse" OR "augmented reality" OR "virtual reality") AND ("sport" OR "sports" OR "esport" OR "e-sport" OR "esports" OR "e-sports" OR "physical education" OR "sports education" OR "sports medicine" OR "fitness" OR "athlete" OR "sport management" OR "sport marketing" OR "sport sponsorship" OR "sport communication" OR "sportsperson")).

The above query resulted in a total of 317 research papers. We further restricted our research to papers of articles category only, which yielded 178 papers. The abstracts of these 178 papers were manually investigated, and 39 irrelevant papers were removed. Hence, we were left with 139 papers, on which the entire research was performed. The descriptive overview of these 139 papers is shown in Fig. 1.

Fig. 1. Descriptive overview

3 Results and Analysis

In this section, we share the results and findings. This Section is further divided into different sub-sections, each depicting its results and insights.

3.1 Annual Scientific Production

Figure 2 shows the annual number of papers published in the domain of metaverse and sports. The results depict that, over the years this research area is gaining attention, with an exponential growth in the count of articles in the years 2022 and 2023 (Till July).

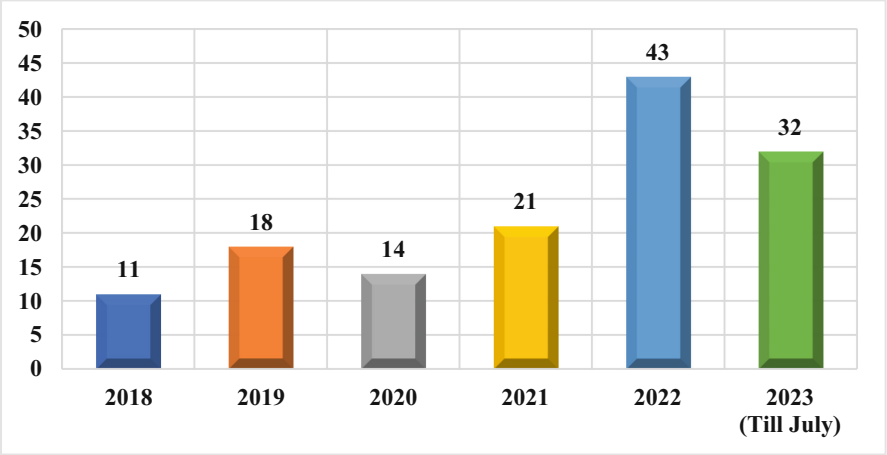

Fig. 2. Annual Scientific Production

3.2 Impactful Countries

Table 1 lists the top 10 countries that have contributed the most to this domain. China tops the list with 42 documents, more than triple as compared to the Korea and USA. Countries from across the globe have made notable contributions.

3.3 Impactful Document

Citation count helps to identify the value of an article in terms of its relevance to the readers. Table 2, lists the documents sorted in order of number of citations in descending order. These articles focus on **(a) sports psychology and behavior analysis** (Düking et al. 2018; Bird 2019; Kim and Ko 2019; Uhm et al. 2020), **(b) physical fitness** (de Melo et al. 2018), **(c) sports pedagogy** (Chang et al. 2019; Ding et al. 2020; Soltani and Morice 2020), **(d) performance analysis** (Faure et al. 2019), and **(e) digital technologies** (Neumann et al. 2017).

3.4 Prominent Topics

To identify the wider spectrum of topics being stressed by the researchers in the domain of metaverse and sports, we performed the topic modeling based on Latent Dirichlet Allocation of the abstracts (Singh et al. 2020). The results obtained have been tabulated in Table 3. In order to identify an ideal number of topics coherence score was calculated for topics (2–20). The results show that 11 topics were ideal for research. Hence, 139 articles were segregated among the identified 11 topics.

(a) **Sports Psychology:** The articles clustered in this domain focus on the studies that analyze the psychology of university students and athletes and human posture analysis while participating in virtual environments (Li 2023; Wang and Xu 2023).

Table 1. Most impactful countries

Country	Number of Articles	Single Country Publication	Multiple Country Publication	Frequency	MCP_Ratio
China	42	33	9	0.302	0.214
Korea	13	9	4	0.094	0.308
USA	13	9	4	0.094	0.308
Germany	11	9	2	0.079	0.182
India	4	4	0	0.029	0.000
Spain	4	4	0	0.029	0.000
Australia	3	2	1	0.022	0.333
Italy	3	2	1	0.022	0.333
Malaysia	3	3	0	0.022	0.000

Table 2. Most cited documents

Article	Total Citations	TCpy	Normalized TC
Kim and Ko (2019)	177	35.40	8.80
Neumann et al. (2017)	135	22.50	4.76
Soltani and Morice (2020)	71	17.75	2.50
Ding et al. (2020)	58	14.50	2.05
Düking et al. (2018)	53	8.83	1.87
de Melo et al. (2018)	38	6.33	1.34
Faure et al. (2019)	37	9.25	1.30
Uhm et al. (2020)	36	9.00	1.27
Chang et al. (2019)	34	8.50	1.20
Bird (2019)	33	8.25	1.16

(b) **Decision Making:** This cluster contains the articles that primarily present the analysis of the decision-making of individuals towards utilizing AR and VR in learning and paras sports (Dias et al. 2021; Dirin et al. 2023).

(c) **Virtual Reality:** VR is the epicenter of the articles in the third cluster which showcases various studies conducted using 360° applications in the domains of health and off-field decisions during live events (Kittel 2019; Vincent and Frewen 2023).

(d) **E-Sports:** E-Sports pose a challenge to maintaining good mental health. The studies in this cluster provide solutions in improving the overall experience while participating in E-Sports and maintaining physical and mental health (Wang et al. 2021; Cai et al. 2022).

Table 3. Results of Topic Modeling

Cluster No.	Cluster Name	Keywords	Article Count
1	Sports Psychology	students, fitness, martial arts, psychological, paper, recognition, algorithms, based, engagement, university	4
2	Decision Making	generated, proportion, athletes, old, physical, presenters, preparing, bodied, youth, collaborative	3
3	Virtual Reality	virtual, reality, sports, development, sense, teaching, game, technology, study	21
4	E-Sports	football, video, based, performance, esport, tracking, image, gaming, trajectory, match	2
5	Sports Pedagogy	virtual, reality, sports, technology, education, physical, research, system, training, teaching	36
6	Healthcare	pain, received, training, weeks, group, team, trial, hospital, postoperative, rehabilitation	4
7	Behavior Analysis	sports, study, intention, analysis, industry, sport, leisure, recognition, model, service differentiation	14
8	Training and Fitness	training, reality, physical, group, study, virtual, fitness, results, performance, augmented	42
9	Sports Injury	jump, differences, laboratory, ar, generate, landing, volleyball, drop, measure, movement	5
10	Technology Adoption	study, technology, sports, adoption, information, consumption, related, vr, purpose, users	5
11	Performance Enhancement	athletes, performance, learning, athlete, systems, practice, adults, older, dynamics	3

(e) **Sports Pedagogy:** Relatively high number of articles clustered in this domain showcases the value and importance that has been given to education and learning systems by the researchers. The articles clustered in this domain indicate incorporating VR in curriculum and physical education can help in providing better assistance to students as well as teachers. The teaching and learning can be made a lot more enjoyable and effective (Zhang et al. 2021; Wang et al. 2022).

(f) **Healthcare:** The articles clustered in the domain of healthcare primarily identify the use of VR and metaverse in gaining endurance performance and minimizing performance anxiety (Huang et al. 2022). The study by Zhang et al. (2022) concludes that immersive experiences of VR promotes active participation in exercise.

(g) **Behavior Analysis:** The study by Kim and Ko (2019) has identified that VR spectatorship amplifies flow experience via vividness, interactivity, and telepresence. Capasa et al. (2022) provided a model of behavioral intention based on the unified theory of acceptance and use of technology (UTAUT) and technology acceptance model (TAM) to assess the curiosity and self-construal of spectators for using VR technology in spectating mega sports events.

(h) **Training and Fitness:** The eighth cluster contains the abstracts for the articles that encourage the use of VR and AR for the purposes of training and fitness. One of the articles in this cluster by Mokmin and Rassy (2022) presents a study that indicates the positive impact of AR technology in the subject of physical education among the students with difficulty in learning. Another article by Ahsan et al. (2022) shows that significant improvement in postural stability was seen among participants in the VR training program.

(i) **Sports Injury:** The article by Adams et al. (2019) focuses on taking the laboratory setting for biomechanical analysis such as measuring knee load to the field that could help curb such injuries. Another article in this cluster by Riehm et al. (2022) proposed a soccer-specific VR header assessment system to assess the athletes for unhealthy, homogeneous movement patterns, and rigid neuromuscular control strategies that were earlier neglected in traditional laboratory assessments.

(j) **Technology Adoption:** In the tenth cluster, the studies highlighting the possibility to adopt AR and VR by consumers or spectators have been discussed. Goebert et al. (2022) in their study concluded that media providers need to introduce AR components, where media giants such as ESPN do not consider AR as a trend. A study by Seong and Hong (2022) based on Extended Planned Behavior Theory shows significant rise in participation in virtual sports because of the COVID-19 pandemic.

(k) **Performance Enhancement**: Stone et al. (2018) used an Ecological dynamics framework to understand the use of VR in performance enhancement of athletes. Gao and Zhang (2023) found that pre-competition mindfulness meditation enhances athletes' attentional control, focus during competition and improves athletic performance.

4 Discussions

Metaverse has gained huge attention in a little time among consumers, spectators media giants, researchers, healthcare professionals, and many more. The findings of this study suggest that primarily the research in the field of metaverse and sports is centered around

using AR and VR technologies with IoT, Cloud Computing, Blockchain, and Artificial Intelligence. The most prominent research domains that were identified through topic modeling are Sports Psychology, Decision Making, VR, E-Sports, Sports Pedagogy, Healthcare, Behavior Analysis, Training and Fitness, Sports Injury, Technology Adoption, and Performance Enhancement. As the metaverse is a newer concept in action, it needs to mature with ongoing research and garnered huge benefits in such a short span of time.

Despite the vast number of benefits, there is a paucity of information about its implementation and adoption at the public/global level. During the inception and early stages of social media, data privacy was a major issue. With the metaverse being susceptible to network attacks, cybersecurity becomes essential to protect data generated and gathered while using the metaverse (Dwivedi et al. 2022). Physical education, sports education, and sports training in the virtual environment of the metaverse should be explored with effective implementation and execution (Demir et al. 2022).

As the health and education of children (the future athletes), is of utmost importance, we propose the use of metaverse with psychopedagogy, nursing, child care, and pediatrics as the domains for future research directions. Similarly, Metaverse along with sports marketing, is an unexplored research domain, which can provide new avenues to the researchers in the domains such as fan engagement, sports advertising, social media marketing, and sports sponsorship.

5 Conclusions

Through the analysis of the Scopus dataset, we have tried to find the sub-fields that have received attention from the researchers in the domain of metaverse and sports. The research in the domain of metaverse and sports is still in its infancy and has got a greater scope. We retrieved only 139 documents for which we performed the topic modeling. The results reveal that studies primarily focus on the impact of metaverse on education, health, fitness, and cognition. The researchers have proposed solutions for improving the quality of teaching and online education through intuitive learning, remote monitoring, improved concentration, and learning efficiency, and performance enhancement through digital means. AR, VR, Blockchain, IoT, wearable devices, and NFTs have been proposed as backbones for the metaverse. Sports marketers, sports managers, and sports advertisers need to think about exploiting metaverse for providing solutions, expand audience/customers, and enhance the monetization of organizations.

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Understanding the Role of Time in Content Selection Decisions on OTT Platforms

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Abstract. The growth of OTT video platforms has simultaneously given rise to various questions related to decision making. While the literature has addressed why consumers use these platforms, the consumer behaviour within these platforms needs to be addressed in detail. Hence, the purpose of this research is to undertake a literature review to identify the factors that affect content selection decisions and categorize them to formulate a conceptual framework. We further extended the conceptual framework by introducing the role of time. The study aims to add to the literature by developing propositions around how time availability shapes the content selection decisions. The research focuses on the need to consider how time influences online consumer behavior.

Keywords: Content selection · Consumer decision · OTT platforms · Time availability · Information cues

1 Introduction

Over The Top (OTT) platforms have disrupted how users view content, enabling them to access content anytime and anywhere. With the large-scale growth of Over the Top (OTT) platforms, Video on Demand (VoD) platforms/OTT video streaming services have attracted attention in the literature, especially after the COVID-19 pandemic, which saw a widespread acceleration in the number of users of OTT video platforms [1, 2]. OTT video streaming services can be defined as online platforms and digital aggregator portals offering widely curated content through the global internet, bypassing the traditional linear model of content delivery through cable TV or satellite services [3]. OTTs employ AI-enabled algorithms that display personalized recommendations to users based on their viewing patterns and the trending options for that day.

The current studies primarily investigate consumption of OTT platforms as a service in general rather than the user behaviour within these platforms [4]. When it comes to decision-making, studies have looked at the behaviour of consumers while choosing a particular OTT subscription [5–7]. However, there is a scarcity in the literature on studies looking at content selection within OTT video platforms. This study tries to answer these questions: 1) What are the key factors that affect content selection behaviour and 2) How

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does time availability affect the content selection decisions of OTT users. The study finds that time as a variable plays an important role in VOD decision making, but it has not received much attention in the available literature. Therefore, the paper develops a conceptual framework by elaborating on the role of time availability in online content selection decisions.

2 Conceptual Framework

The current works related to decision-making within the platforms are exploratory in nature with multiple theories in use. Motivation theory and information cue based heuristic decision making have been used to explain the role of multiple factors in leading to content selection [6, 8]. Whereas Elaboration Likelihood Model and Bandwagon effect have been used to identify the role of thumbnails and texts in content selection decisions. The literature reveals several factors that lead to content selection decisions in OTT platforms. These factors are actor, algorithmic recommendations, genre/category, mood/emotions, online reviews/ratings, peer recommendations/peer pressure, text description and thumbnail. Yet, most of the studies are more empirical and in a standalone nature without a solid conceptual framework suited to the specific context of OTT platforms. Therefore, the first task is to bring all these significant factors mentioned in the literature to come up with a conceptual framework. This begins with the assumption that the effort required to make consumer decisions in online settings varies from that of offline [9].

In previous studies, the same factors are classified into different categories based on theoretical application. Guetzit et al. [6] has found that extrinsic and intrinsic motivation affects the content decision, and they were grouped together under the category of motivation. But, another study by Dogruel [8] based on information cues has included online ratings, user reviews under the category of crowd-related cues which could possibly be brought under extrinsic motivation based on motivation theory. Similarly, actors and genres which act as product cues in the same study could be classified as intrinsic motivation based on motivation theory. So, our conceptual framework begins with classifying all the important factors under larger universal categories through combining disparate concepts addressing content selection decisions. These categories are:

Intrinsic Preferences

Intrinsic preferences are the subjective level interests, biases and thoughts of the user that affect content decisions. It is the user's self-determined behavior. It includes factors such as actor, genre and mood/emotion of the user. The role of actors in viewers' content decision making has been widely discussed [10–12]. Though the research has been limited in the context of OTT platforms, actors are found to motivate users to select the content [8]. The current studies find that when people do not have an intention of watching a particular programme, high subjective factors of the user's mood and emotions influence the content watching decision [13].

The genre of the video acts as a trigger event for selecting a video [14]. When users are undecided, the categorization in OTT platforms based on genres or language is looked at as the first step. Based on the compatibility between the genre and the mood of the user, a decision about what to watch is made. Individuals' choices of media selection

in general are driven by their mood [15]. Viewers' motive to watch content is either to increase their pleasure or reduce their pain. Hence, the same person in a good mood shall prefer different content when in a bad mood [16].

External Stimuli

External stimuli are the factors outside the subjective self of the user that affect the content decisions. These are the motivations that are external to the users' self. It includes factors such as algorithmic recommendations, online ratings/reviews and peer recommendations. Algorithms play the role of content filtering and persuasion [17]. It helps in avoiding choice overload and maximizing user relevance [18]. If users do not find the exact video based on their search, they browse through the related videos [14]. The reviews from social media and other such online platforms are very influential when it comes to the decision of choosing content [2]. It helps in ensuring that there is no waste of time. As the rating increases, the number of viewers increases on the OTT platforms [19]. Peer suggestions are given more credibility when it comes to the decision to watch a content [20, 21]. These users also receive and provide reviews/suggestions of movies frequently [6].

Information Cues

Unlike watching movies through movie halls which involve higher economic risks, watching them through OTT platforms is less risky as a subscription offers multiple content that could be watched at any time in contrast to TV which is time constrained based on 24 * 7 schedule. Hence, information cues become very vital for selecting content in OTT platforms [8]. It helps in understanding the relevance of video [22]. It includes text description and thumbnails. Thumbnails are meta level options along with a title, tag, and outline that help to increase the viewership of online videos [23]. The thumbnail based on contextual relevance and visual quality increases the chance of content selection [24, 25]. Thumbnail image is crucial as it evokes interest leading to content selection [26]. Text description also impacts the decision as it reveals more details on the content. More textual information is found to increase the views [27].

2.1 Interaction Between Factors

Intrinsic preference and External stimuli could directly lead to content decisions based on their strength. For instance, if the user is a fan of a particular actor or if a close friend recommends watching a movie immediately, it may directly lead to a content decision making the user search directly for a movie. Intrinsic preference and External stimuli could also interact with each other. In such cases, it leads to certain search behaviours [28] These search behaviours are direct search or direct browse or first search and then browse. The type of search behaviour depends on the individual strength of intrinsic preference and external stimuli and the strength of interaction between them (Fig. 1).

Once the user undertakes a particular search behaviour, the user finds thumbnails and texts which act as the information cue for a particular content. Irrespective of strong intrinsic preference or external stimuli or an interaction between them, the information cues validate the final content selection. The information cues mentioned here are slightly different from Dogruel [8], which is a combination of crowd related cues and product cues. Here, it means the thumbnails and texts inform the users about the product

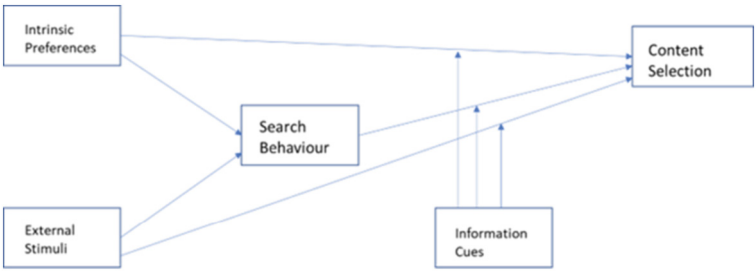

Fig. 1. Conceptual Framework

characteristics and quality such as title, genre, story, online ratings, actors etc. (these details vary based on the OTT platforms). If the user comes across a recommendation that matches their mood, the information cues obtained from thumbnails and text must match the expectations of the user which will lead to content selection. Even if the extrinsic stimuli or intrinsic preferences are strong, thumbnails with titles are required to finally select the movie. In such cases with strong preferences or stimuli, the text would not have much impact.

3 Time and Decision Making

The conceptual framework derived from the literature is helpful to understand the content selection decision. Yet, there lies the possibility of improving the conceptual framework by bringing the question of time availability into it. The value of time varies among individuals as there is only a finite amount of time available in a day. Therefore, there will be differences in the decisions made by individuals based on the costs they attach with time. When it comes to the question of OTT platforms, the influence of time on content selection decisions becomes even more complicated. Once an individual makes the choice of a particular or multiple OTT video platforms, how they make the online viewing decisions is an unexplored area. One of the major important factors of the competitive superiority of OTT video platforms over traditional media like television is its convenience [29, 30]. This leads to a further probe into how time as a resource affects the viewing decisions in a service whose competitive superiority over the former technological predecessor is the convenience offered in its ability to suit the demands of the consumer's available time.

Human decision-making is influenced by various factors such as time, money, and information [31]. In the context of online viewing decisions, the decision encompasses both the question of what to watch and how much time to give to the question of what to watch. The process of making decisions and the final chosen decision could vary based on the availability of time. People behave differently when they do not have sufficient time to make a well-informed decision. Some of them may end up thinking very effectively leading to a better decision than normal, while some may do worse than normal [32]. In general, the effects of such situations in decision-making are a reduction in information search and processing, forgetting important data, and strategy of information filtration which helps in processing important information first [32]. It

could probably lead people to process the large amount of content through heuristic shortcuts such as looking at information cues, they find relevant. In the case of OTT video platforms, these questions of time scarcity and information filtration mechanisms are still unknown.

The lack of availability of time is a criterion that may determine the judgment of the relevance of a video [33]. Taking the case of online TV clips, Yoon et al., [4] uses the consumption values theory to highlight how these short clips of TV programs add to the functional value for users as it gives them convenience by saving time. Though the context here is different as it saves time by avoiding the need for watching the entire program, it also makes way to the question of how convenience or time-saving acts with respect to content decisions. Many consumers who do not have enough time available to use OTT platforms consider stopping its usage and subscription [2]. Most importantly, a user's time engagement with the platform (either heavy or light) is also bound to affect the content selection process. It is found that heavy users of Youtube are more likely to watch YouTube recommended videos than light users due to the cultivation of dependency on YouTube because of frequent usage [34].

The observations from the literature prove that time availability has an important role to play in the context of OTT platforms. Yet, the exact nature of the role of time in the case of content decisions within the OTT platforms is unknown. As time convenience is considered a competitive superiority and perceived advantage of OTT platforms, it needs to be essentially understood to constitute the whole notion of OTT as a video streaming service. Therefore, the individual time availability of consumers would affect the usage behaviour and decisions of the consumers within the platforms.

4 Impact of Time Availability on Content Selection

The availability of time or the lack of it drives content selection behaviours among users based on the type of user-time relationship. Users constrained by time with a lack of liberty to browse through vast catalogues [35] may prefer relying on preconceived notions of popular content. Therefore, external stimuli like peer reviews, popularity across social media, et al., may take the centre stage when deciding to click on a specific show or movie when users are not ideally able to devote long hours of personal time watching OTT content. It can be proposed that time could play a significant role in deciding what to watch on the go as a large amount of content is being watched on mobile phones. This implies paucity of time may lead to internal preferences being sidelined as intuitive choices and elaborate thoughts may not be crafted under time pressures increasing the influence of external stimuli [36].

External stimuli like algorithmic recommendations, a good word from friends or family, and online reviews already help form an opinion about a specific content prior to the actual occasion of decision-making. Users may quickly search for a recently popular content piece around them during short runs of OTT viewing as against browsing for relevant content. Alternatively, algorithmic recommendations or top lists churns out content lists based on users' viewing habits and the search-cum-watch behaviour of users with similar demographics. If the user has enough time at hand, they may continue browsing until they find product cues like genre or actor that will be compatible with external stimuli based on past suggestions by their peers. Or they may browse until they find content

that is compatible with their intrinsic preferences i.e., mood. In case of high external or intrinsic factors, they might directly search for some specific content. If there are no high external or intrinsic factors, they might directly search and then browse for content. Therefore, search behaviour does not directly lead to specific content every time. If there is a strong significant factor, it might lead to content selection, else the user looks for product cues that interact with the time availability which would affect the motivation to direct toward relevant content. Here, if a user finds a movie of their favourite actor while browsing, it acts as an external stimulus based on algorithmic recommendation leading them to consider it. If the user does not have enough time, the user would select it or if there is enough time, the user might search for movies of the same actor. Therefore, we present the following propositions:

Proposition 1a: As the time availability decreases, the strength of internal preferences decreases determining the choice of content to watch on OTT platforms.

Proposition 1b: As the time availability decreases, the strength of external stimuli increases determining the choice of content to watch on OTT platforms.

Users with ample time to watch content on OTT platforms tend to spend considerable time engaging more with the platform, given that they don't have a predetermined choice. This is dependent on their mood, interests, and external stimuli at the given point in time. However, in situations of constrained time, users may simply rely on the algorithmic suggestions and currently trending content because of their limited browsing conditions or directly search their predetermined choice. While the users with more disposable time in their hands would spend more time and explore the platform for suitable content - searching and filtering by genre, language, actors, or title thus expanding their choice. Therefore, the presented proposition below highlights this impact of time availability in the search behaviour.

Proposition 2: Time availability affects search behaviour by increasing direct search queries and decreasing browsing time.

When users search for content, they assess thumbnails and text for relevance to their motivation. In time-constrained situations, users often choose content based on immediate information cues that align with their preferences or external stimuli. The abundance of choices on OTT platforms can overwhelm users. They may continue browsing until they find content matching their mood or recommended by peers. Thumbnails play a critical role in content selection, simplifying decision-making in visually appealing ways [37]. In time-sensitive scenarios, users may click on thumbnails or skim text for keywords, relying on gathered information and intrinsic responses to make their final choice. Notably, thumbnails take precedence over text descriptions, with platforms like Netflix customizing them for different user groups. This leads to following propositions (Fig. 2):

Proposition 3a: Time availability influences the relationship between information cues and content selection.

Proposition 3b: As the time availability decreases, the importance of thumbnails increases over the text.

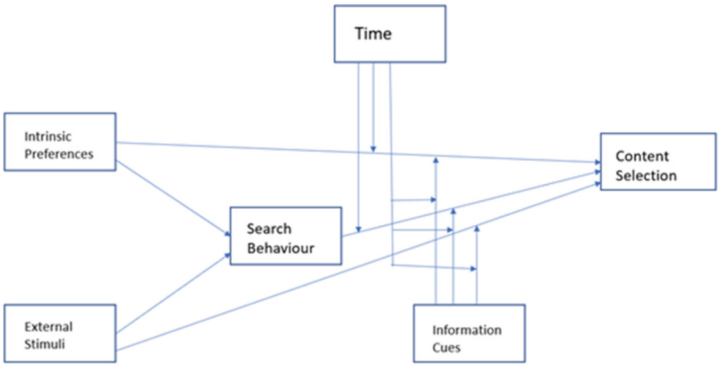

Fig. 2. Role of Time in Content Selection Decision

5 Conclusion

The study primarily explores the role of time as an important factor in OTT content selection. The available literature around OTT platforms and the generic consumer decision-making processes throw light on the significance of many factors and how they interact with each other in affecting the choices of video content on streaming platforms. Choosing content is complicated with intrinsic preferences, product cues, and information cues playing an important role, while time availability influences all these factors individually and in their interaction with each other. The next step forward is to test its relevance. An empirical validation of this conceptual framework will be done through interviewing the users of OTT platforms.

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How Successful Online Platforms Create Value?

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Abstract. Out of several thousands of startups, only a few achieve success. Those who achieve a certain level of success witness stiff competition from different spheres. They also face a diminution of value proposition and waning network effects. How can they address such issues? In this article, we examine the practices of twelve Indian unicorns and generalize the 'reconfiguration' of the value proposition as a common practice among these unicorns. All unicorns reconfigure, though the flavor may be different. Value reconfiguration must strengthen an online platform's existing network effects. This article presents strategies for startups to design and grow their businesses.

Keywords: Online Platforms · Value Generation · Value Reconfiguration · Startups

1 Introduction

"A full 92% of start-ups fail in the first three years—but failure is not inevitable". – Jamie Pride

Start-ups begin with a unique value proposition and desire to become a unicorn – a privately held start-up valued at over USD1 billion. However, very few start-ups realize this dream. Those that realize the dream find the competitive space quite different from the one they began with. The competitors are diverse and come from different arenas. The initial value proposition no longer holds ground. To remain competitive, they need to go beyond better matchmaking and reconfigure their value proposition to establish barriers, lest they get displaced by competition [14, 16]. How do unicorns address these concerns?

Start-ups dream of becoming unicorns, but only a few make it to the top in the e-commerce platform space. Reference to ecommerce space is inevitable with the term start-ups today as many start-ups are coming up as ecommerce platforms, utilizing multi-sided intermediation to facilitate exchanges between consumers and suppliers, thus creating value within their ecosystems [2]. Startups in e-commerce usually act as intermediaries between two or more groups of users using digital technology [15, 18]. Cusumano [6] identify four steps that online platforms must address to become successful platforms. The first step entails identifying the roles different actors (buyers/sellers/complementors) play on the platform, those who will play these roles, and

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when to onboard them. The second step entails igniting or engineering the network effects on the user/complementor base. It is a difficult step and usually entails subsidizing one side of the network to attract the other side. The third step involves strategies to monetize these network effects without depressing them. These include deter-mining strategies on how the cash flow and profits would flow sustainably and which sides of the platform should benefit from the subsidies. The last step is to establish and enforce ecosystem rules. The platforms have to determine measures to increase the quality of the engagement on the platform, reduce low-quality transactions, and allow members to build a reputation on the platform.

We examine how successful online platforms create value in practice based on Cusumano [6] framework. We consider platforms that have achieved unicorn status as having attained a level of success. Among startups' categories, the term unicorn refers to the category of private high-growth startup companies, worth one billion dollars or more [3, 8, 9], plus appreciation within a few years of their inception [13] and highly innovative [7]. They represent a high-risk model with considerable turbulence and volatility [5]; therefore, entrepreneurs are seeking changes actively and constantly, or making strategic choices, to overcome the problems they face and lead them to business success [12]. Achieving a unicorn status is not a guarantee of success, but it indicates investors' confidence in the platform and comparatively robust approach taken by the entrepreneur. Hence, we examine: what can platform startups learn from the practices of successful platforms for building their own business? How do successful online platforms generate value? We examine the practices of twelve Indian unicorns from different e-commerce sectors. India is witnessing an e-commerce revolution propelled by cheaper internet and higher smartphone penetration. It has become the third-largest ecosystem after US and China in terms of the number of startups. As of August 2022, there are more than 77,000 recognized startups in 56 diverse industrial sectors, out of which around 107 startups have acquired unicorn status as of September 2022. As India is witnessing an e-commerce revolution propelled by cheaper internet and higher smartphone penetration, we have a rich set of torch-bearing insights for aspiring unicorns, considering that only a few startup platforms have acquired unicorn status compared to the number of registered startups (0.14%).

Two prominent findings emerge from our study of Indian Unicorns. First, they usually go through some experimentation before they can create value. Once they pivot on a certain value proposition, they work hard to strengthen network effects between the platform sides and reduce multi-homing costs among their participants. Second, once they are substantially established, they reconfigure their value proposition armed with the availability of real transaction data. Unicorns reconfigure, although the way they do so, however, may be different. The prevalence of this practice in most unicorns, selected from diverse sectors, renders evidence and support for generalization. Thus, we elaborate upon the third step of Cusumano et al. (2019) framework. Since successful online platform startups reconfigure value only when they have achieved some level of success, we add value reconfiguration as the fifth step in building an online platform.

Cusumano [6] four steps are generic steps that are endorsed by several other scholars also. For example, [10] argues that online platforms should answer four strategic questions for constructing and governing themselves. These include: the number of sides to

be brought on board, designing the sides of the platform (who should be onboarded), making the pricing decisions (which side should be subsidized and which side should pay), and establishing the governance rules for the platform. These steps apply to all platforms, although their specific applications may differ in different sectors [4]. For example, as per [4], the governance modes applicable in most sectors do not work in the healthcare sector, given its complexities. In other words, the nuances of some sectors demand different treatment of the platform business. Therefore, we use these four steps in a generic sense for examining Unicorn practices as proposed by Cusumano [6].

2 Method

We examined several start-ups in India and selected those that have become unicorns within the last five years. We selected unicorns from various sectors- Flipkart (B2C E-retail), Zomato (food Delivery), Zerodha (Fintech), Ola (transportation), Paytm & Cred (Fintech), Byjus (Edtech), Nykaa (Cosmetic retail), Oyo (Hospitality), Pharmeasy (Healthcare), Droom (Automotive retail), Udaan (B2b e-retail), Coindcx (crypto exchange0. We studied the website of each unicorn to understand their present offerings to all sides of their network. We then collected archival data for each of these unicorns. The data included online news, and magazine articles. We identified specific themes from these articles and then searched for such themes for each unicorn. Thus, we conducted multiple iterations till no new themes emerged. We then manually coded these themes to create a best practice. Then we collected interviews conducted by leading media houses for each of these unicorns to examine their perspective. We then categorized these practices in Cusumao [6] four-step framework.

3 Findings-How Unicorns Generate Value

We coded and classified the practices of the twelve Indian unicorns using Cusumano [6] framework. The choice of the start-ups is done to cover variety of arenas for near universal applicability. We also found that all unicorns reconfigured their value proposition after achieving a level of success. We coded this step as value reconfiguration.

3.1 Choose the Market Sides

Pivot on Prior Experience. Choosing market sides involves identifying the players who will participate on the platform. Although it seems obvious in retrospect, it is a big challenge for platforms. We found that most unicorns benefitted from their prior experience in choosing market sides. Byju's founder, Raveendran, leveraged upon the reputation developed through offline workshops for Common Admission Test. After conducting these offline workshops, it became apparent to him to build quality content and offer it to prospective candidates. Subsequently, the content creator became one side, and the prospective candidates became the other. Byju is now the leader in the Indian EdTech space. Similarly, Udaan spent some time building reputation among buyers and sellers. It managed logistics for them before starting its B2B marketplace model.

Familiarity played a vital role in the B2B segment in India, given its rural flavor. Flip-kart copied the online retailing model from Amazon. Its founders worked for Amazon and gained confidence in the get-big-fast mantra of Amazon before launching Flipkart in India.

3.2 Solve the Chicken-or-Egg Problem

There are two steps in solving the chicken-or-egg problem. The first is to decide which platform side to onboard first, and the second is to scale the user base. The side that a platform wishes to subsidize should be onboarded first. The side that stands to gain is onboarded later. Platforms (especially aggregators) sometimes onboard both sides in a zig-zag fashion. The second step involves generating network effects between the two sides. Once a platform engineers network effects, the platform grows automatically. However, the question of which side to build first is a challenging one. We found five prominent strategies that unicorns practice to solve these two issues.

Build Awareness. Unicorns create awareness about their platforms through advertisements and celebrity endorsements. While they can advertise digitally, most unicorns still go the traditional way. Cred built awareness through offline advertisements and exclusive events (such as during cricket sports). Flipkart and Byju used television advertisements to raise awareness. Nykaa publicized its tie-up with celebrities.

Create Communities and Educate Users. Some unicorns engineer the creation of a high-potential concentrated prospect user base by building communities and by educating the masses. They attract pro-spective users by facilitating a platform for a community of users, enabling prospects to exchange knowledge and answer mutual queries. For example, Nykaa has expert blogs on its website with links for the recommendations of the product and a community on beauty and personal care. Similarly, Zerodha maintains a trading Q&A community where users can discuss issues related to trading with each other. In domains with a steep learning curve, platforms provide free educational content. For example, Zerodha has built a varsity, a one-stop-shop reference for advice on the stock market. It also has tutorials and advice on getting the most out of the market. Coindcx supports a portal – DCX learn – a blockchain and cryptocurrency academy. Pharmeasy and Nykaa have expert blogs by certified pharmacists and known beauty experts. All of this helps acquaint the brand with prospective users.

Engineer Virality. When there is no natural virality[1] in a platform's service, they need to engineer network effects. Once the network effects kick in, the platform grows on its own. Referral benefit is one common strategy through which they leverage the social circle of the existing user base and draw other potential users. Platforms incentivize the existing userbase to refer their friends and acquaintances to the platform in lieu of rewards points or cashback redeemable in future transactions. Droom offers miles for referring a friend's phone number and email ID. Some platforms offer revenue sharing as an incentive for referral. Zerodha, for example, has a client-to-client model whereby it shares 10% of brokerage revenue generated from all the clients that one refers.

[1] Virality refers to the ability of a platform to generate network effects. If a platform becomes quickly viral, it will generate strong network effects.

Incentivize Trials. The unicorns incentivize prospects by offering discounts and rebates or free trials. Platforms use the freemium model when the product or the service is repeatable, requires a subscription, or has a strong experiential flavor. They offer the product or the service experience free for a limited period or limited instances. For example, Byju's offers its superior patented educational content free for 15 days. Online retailers conduct flash sales, particularly during festive periods. Flash sales are heavily discounted goods offered on sale for a very short period. These sales attract a large base of customers in a relatively short period, create brand awareness, and increase the visibility of the websites on the deal sites and blogs. It also helps unload excess inventory, thus reducing operational costsFlash sales work very well for the infrequent non-cyclic categories, mostly impulse purchases, such as fashion, beauty, jewelry, and electronics. Flipkart has successfully conducted big billion days twice a year for many years, generated huge sales, and expanded its user base. Nykaa has also applied this strategy successfully.

Other platforms also offer discounts and rebates in the initial period in product categories that are frequent and repeatable. Paytm in the initial phases, incentivized peer-to-peer monetary transactions in the form of cashback. It is now shifting its discount and cashback strategy to offline merchant (local retail stores) payments made by users using Paytm. Cred offers rewards for any registered credit card payment done by the customers in time in the form of cred gems. Pharmeasy provides deep discounts on medicines ordered through its website compared to local pharmacy stores. Droom offers free insurance on certain used cars based on its assessment of their fitness. Similarly, Zomato, Ola, and Oyo also provided deep discounts when they started.

Acquire or Partner with an Existing Userbase. Platforms need to build a critical mass for leveraging the network effects. They acquire or ally with other businesses serving a similar or related need. Most e-commerce platforms acquire or partner with incumbents to quickly build the user base and, in some cases, expand their product/service offerings. Pharmeasy, a unicorn in medicine delivery, acquired existing medical diagnostics giant Thyrocare. Similarly, to expand its reach, OYO, which operates in budget accommodation, partnered with Yatra.com – a flight and hotel aggregator. Paytm acquired full-scale businesses' Insider' and 'Ticketing new' to enter the ticketing business. Ola, a cab aggregator, acquired 'taxi for sure,' which was into cab rentals to access its user base. When Ola decided to enter the food delivery space independently, it did not succeed. Its service took off with the acquisition of Food Panda's Indian venture, which was already in the food delivery business.

3.3 Design the Business Model

As the platforms create value and build a user base, they need to monetize it. Platforms create value by matchmaking, reducing friction, offering complimentary services, complimentary technology sales, and advertising. Although pricing strategies differ depending on the value created by the platform, they should essentially increase a user's willingness to revisit the site or renew the subscription. Customers would be willing to revisit the site/renew the subscription if (i) they ascribe a greater value to the offering from the platform and/or if (ii) there are barriers to multihoming (being present on multiple

platforms). Advertisers would be willing to come to the site with a large user base and a unique offering that can be used for a specific advertising genre. Accordingly, we witness three prominent strategies among the sampled unicorns.

Improve the Relevance and Accuracy of Matchmaking. Their service depends on how relevant/accurate the match is. The study brought out two distinct themes in this regard. Unicorns use technological advances like GPS-based location tracking, cloud-based real-time route optimizers, point-of-sale billing, chatbots for initial query resolution of customers, etc. The second is to develop insights based on data for better offerings to the users, such as generating creditworthiness scores, personalized recommendations, insights, and forecasts. "Data is the new oil" was coined initially by Clive Humby, a British mathematician and data science entrepreneur. It gained attention when Gartner's Vice President, Peter Sondergaard, mentioned, "Information is the oil of the 21st century, and analytics is the combustion engine."[2]

Unicorns utilize advances in artificial intelligence and machine learning to generate business insights. Structured data, such as transactional and behavioral data, is used to create alerts, creditworthiness, supply chain optimization, inventory forecasting for sellers, business insights from sellers, and recommendation engines to recommend products bought together. Platforms use GPS technology to improve operations by accurately tracking pickup and delivery by delivery partners and relevant ride-sharing solutions with accurate estimates. Zomato, for example, uses GPS-enabled technology solutions integrated with order management to manage pickup and deliveries. Zerodha uses API frameworks to offer its infrastructure as a platform for other fintech players in the ecosystem. Byjus analyses user interaction data to create personal learning journeys through videos, questions, adaptive flows, quizzes, flashcards, etc.

Platforms also generate insights from unstructured data. Zomato, for example, uses natural language processing (NLP) to analyze sentiment from customer reviews and detect fake reviews, visual analytics for object detection, and optical character recognition for digitizing restaurant menus. This, along with purchase patterns, provides insights to Flipkart, Zomato, and Nykaa for launching private labels. Oyo leverages NLP-based sentiment analysis on social media data to rate hotels. NLP techniques are also used to create voice-based search apps. Udaan's B2B platform connects retailers with distributors utilizing this technology. Flipkart plans to leverage deep learning for language translation to offer its website in regional languages. Nykaa and Paytm use optical character recognition (OCR) for digital cataloging. Droom does the same to create virtual inspection tools along with virtual reality for prospective buyers to aid in self-discovery.

They have core teams of full data scientists, business analysts, machine learning engineers, and a few full-stack engineers. They invest in creating data lakes to store and maintain the data and leverage cloud infrastructure. They also acquire other set ups with core offerings in data analytics and technology-based tools.

Increase Multihoming and Switching Costs. Once platforms gain a substantial user base, they tend to block the users on either or both sides. Unicorns generally use soft strategies to create offerings that potentially discourage users from multihoming. There

[2] https://www.geospatialworld.net/prime/business-and-industry-trends/data-was-analytics-is-the-new-oil/.

are several ways to do so. Droom – a platform for used vehicle dealers – organizes periodic regional consortiums known as 'Sellers Meet' where dealers share best practices, get updates on Droom's products and services, and recognize star sellers from different categories. Paytm and Flipkart offer entertainment content on their platforms. Ola and Oyo provide financial assistance to users and thus bind them. Ola provides leasing and financing services to cab drivers, who remain hooked to the platform until at least they are free of debt. Similarly, Oyo offers financial assistance to hotel owners to transform their properties. Flipkart also provides financing options to users on certain purchases. It has exclusive partnerships with prominent banks and credit cards to offer discounts on purchases made on its platform. Nykaa allows repeat orders according to the user-suggested frequency of its products. Oyo offers a subscription plan for frequent travelers (Oyo Wizard). Byju's through its intellectual property rights over its learning content makes customers visit the site repeatedly to consume it.

Monetize Through Targeted Advertisement. Almost all unicorns attempt to increase the sources of their revenue generation. We witness the ingenious ways that platforms articulate to do the same. They already have a vast user base that advertisers can use for targeted advertisements. For example, Zomato hosts banner ads on its website where new restaurants can advertise. Since Zomato has niche traffic of users interested in trying a variety of foods, new restaurants have a better chance of gaining users. Similarly, firms offering car accessories get a better conversion rate by advertising on Droom – which is into sales of used vehicles and is a discovery platform for automobiles.

The unicorns also leverage data from users' transactions and browsing behavior and sell insights to advertisers for better targeting. Paytm and Droom, for example, publish facts about their targeted user base to allure advertisers. Similarly, Cred having access to creditworthy users offers a platform called Discover. Here, premium brands can list products or services that a premium customer base can afford.

3.4 Establish and Enforce Ecosystem Rules

Platforms need to establish governance rules as to who can and who cannot participate in the platform. Almost all platforms suffer from the problem of quality. For example, YouTube suffers from fake and poor-quality videos; social media platforms suffer from fake listings and anonymous trollers; Amazon and Flipkart suffer from fake reviews, inferior quality products, etc. Therefore, e-commerce platforms have an important responsibility to prune poor transactions on their platform. They need to put measures in place to govern the quality of the users and transactions on their platform. Even in loosely moderated platforms, the platforms must foster trust among their users. The most important strategy platforms take constantly building upon their users' trust.

Foster Trust. Unicorns build several mechanisms on the platform to foster trust. These include mechanisms for capturing testimonials, reviews, and ratings according to the need of the product or service. Platforms leverage analytics to identify highly probable fake reviews. Exclusive selection of the user base signals quality participation in the platform, as done in Cred. Similarly, exclusive tie-ups with brands, in the case of Nykaa, are a signal of quality. Zerodha displays recognition from the highest stock exchange

in India on its website. Nykaa, Zomato, and Flipkart offered the cash-on-delivery policy to build initial trust among users. Favorable return policies also foster trust among buyers. Some platforms use trust seals. Oyo, for example, uses social media data to rate its budget accommodations (Oyo assured). Coindcx is a certified platform for cryptocurrency exchange (ISO certified) and offers insurance for user funds (Bitgo insured). Droom certifies sellers on its platform that meet its minimum criteria. Flipkart places an assured seal on products considering ratings, customer returns, seller cancellations, and other performance-related factors that determine customer experience. It has also built a seller protection fund as insurance against damaged products. Similarly, Oyo offers Oyo-assured accommodations to its customers.

3.5 Value Reconfiguration

We found certain strategies that all unicorns practiced after attaining success. We could not clearly classify them in any of the four steps and hence coded them as value reconfiguration. We discuss these strategies now.

Diversify Offerings. With the already existing and developed user base, platforms expand their product offerings to cross-sell them a broader category of products and services. Nykaa started with beauty products and expanded into fashion, mom, and baby care. Paytm started as a digital wallet and expanded into related products, such as investments, insurance, retail, and content. Similarly, Zomato expanded from a restaurant listing to a food delivery and table reservation platform. Coindcx expanded to cover future traders. Zerodha diversified to offer mutual funds. Pharmeasy diversified to selling medical equipment and health insurance. Ola expanded to provide cab rental, interstate cabs, cab sharing, and auto rentals. Some unicorns acquired other firms to diversify. Oyo started as a platform for budget accommodation and acquired firms in the Leisure home segment. Similarly, Flipkart acquired Myntra to diversify in the fashion and apparel space. Byju's covers the complete learning needs from K5-K12, including materials for preparation. Zomato offers Zomato Pure – supply chain management of the raw material for the restaurants. Cred leveraging its niche user base has extended offerings like peer-to-peer lending, classified services, such as renting apartments with minimal deposit amounts, as they are already creditworthy. Udaan, a B2B marketplace started offering products on credit by considering the transaction history of the retailer. Droom forayed into insurance, loans, variety in vehicles, and providing historical data of cars. It also invested in the last-mile delivery of the car to the consumer.

Change Value Configuration. Quite commonly, unicorns change their value configuration to capture more value. Private labeling is common among marketplaces as they recognize users' shopping preferences- Flipkart lends unbranded products its name and sells them at the most preferred price on its platform; Oyo shifted from the hotel aggregation model to the franchise to reduce operational costs and improve service; Ola is

venturing into cloud kitchen. Paytm offers point-of-sales billing and accounting software. Zomato provides insights for restaurants so that they can better target customers. Pharmeasy delivers business insights to sellers and offline pharmacies. Flipkart provides insights related to inventory as well as recommendations to sellers. Oyo offers property makeovers and financial assistance to property owners. Udaan also offers analytics-driven insights to suppliers and retailers.

Build an Omnichannel Presence. Most successful platforms make efforts to expand customer reach by being present across other channels in one or more. Nykaa has expanded and opened offline stores and kiosks in offline shopping malls, where users can purchase and get suggestions on beauty and fashion segment store staff. Similarly, Flipkart is opening offline experience centers – buy zones, where customers can walk in to get the touch and feel of the product before ordering online. Some unicorns host offline events in their related domain. Zomato hosts food festivals whereby many restaurants can participate in their food offerings. Nykaa hosts many beauty events and pop-up shopping events to engage customers offline. Byju's has also applied the alternate channel model to reach customers by facilitating live interactions and tutoring.

Shape the Ecosystem. Unicorns engage with policymakers to influence the future course of the ecosystem. Coindcx plans to use the funds to set up R&D and public discourse. It is working with the government to introduce favorable regulations. It also educates users about cryptocurrency. Pharmeasy is working with competitors and engaging with government bodies to prepare rules for this space. It is also helping local offline retailers to digitalize their records. Oyo entered into a strategic partnership with prominent government agencies, such as the National Institute of Tourism and Hospitality Management (NITHM) to shape skill development. Ola and Siemens have in-vested in India's electronic vehicle manufacturing facility to launch its electric scooters. They are working with the Tamil Nadu (a state in India) government to set up a network of electric charging points crucial for adopting electric scooters. It is a pioneering step as electric vehicles, especially two-wheelers, are coming in a big way in India and would play a pivotal role in the delivery industry, thus helping India meet its commitment to reduce its carbon footprint. Flipkart has launched its app and website in Indian regional languages for deeper penetration into Tier 3 and 4 cities. Zerodha is providing fintech firms with the platform infrastructure and acting as an incubator for some of the fintech firms.

4 Discussion

What can we learn from Unicorn practices? Figure 2 summarizes the findings of this study along the Cusumano [6] framework. Addressing the four steps is a difficult challenge for online platform startups. One thing is clear. Most Unicorns go through a period of experimentation before they can bring forth a solid value proposition that can hold ground. Online platform startups need to enhance network effects to grow. Building network effects may entail subsidizing a side of the platform, enhance the accuracy of their matchmaking and increase multi-homing costs for their users by providing better value and build trust among their participants to improve their platform experience.

Secondly, platforms need to be in a continuous search for creating better value. We term this phenomenon as value reconfiguration. They need to capture a greater market share before the user base drifts, negative network effects kick in, disruptive innovations appear, or competitors make sly [14, 16]. We witness that all unicorns reconfigure value once they grow substantially in the marketplace though the flavor of reconfiguration may be different. They identify the core driver of their value. Most unicorns have a dedicated analytics team that looks into their platform behavior and learn whether users cluster towards any particular product, restaurant, and so on and leverage this information to provide consultancy services, launch private labels, enhance more services around such behavior, etc. However, they must also exercise cautions while drawing insights from the data. In doing so, the analyst may miss out on less apparent but equally important transactions due to cognitive biases [11] and bounded rationality.[3] For example, like only going for 'head' in the long-tail phenomena may prompt analyst to overlook value in torso and long-tail products; which are beneficial in an e-commerce business [1].

Analyzing customer data to stifle competition invites the attention of anti-competitive regulatory bodies. If convicted, the penalties could be very severe. For example, the European Commission antitrust lawsuit against Microsoft for failing to provide interface information led Microsoft to pay a total of $1.52 billion for non-compliance.[4] Zomato also came under the scanner of the Competition Commission of India, which highlighted the possibility of using consumer data to stifle competition. To circumvent these challenges, Unicorns are leveraging the data they own to create frameworks that would benefit the society at large to signal their contribution to build a welfare state. Zomato has come with platform (Zomato Food Trend) accessible to the general public and restaurant partners free of charge to provide insights by analyzing data from millions of transactions across hundreds of Indian cities. Paytm has announced building AI software stack to capture fraudulent transactions, leveraging access to large amount its transaction data to export technology solutions. Hence, this study extends the Cusumano [6] framework and can assist practitioners in understanding how Unicorns create value (Fig. 1).

5 Conclusion

What can online platforms learn from unicorn practices? It is not enough to build a unique value proposition. That is good for starting and getting going. Most startup platforms must experiment with the model before solving the chicken and egg problem. Once the network effects kick in and become sufficiently strong, they should look to build added value around their core value proposition. The value reconfiguration must strengthen an online platform's existing network effects for a firm to become stronger [17]. This article provides several strategies that successful online platforms take to create value. Online platform startups can take these lessons to improve their platform and achieve success in the digital landscape. While the findings pertain to Indian ecosystem, they are quite generalizable except for contextual differences. First, online platform startups in Indian ecosystem have to do substantial work in creating the ecosystem. Creating the ecosystem

[3] https://amturing.acm.org/award_winners/simon_1031467.cfm.

[4] https://money.cnn.com/2007/02/22/technology/microsoft_alcatel/index.htm.

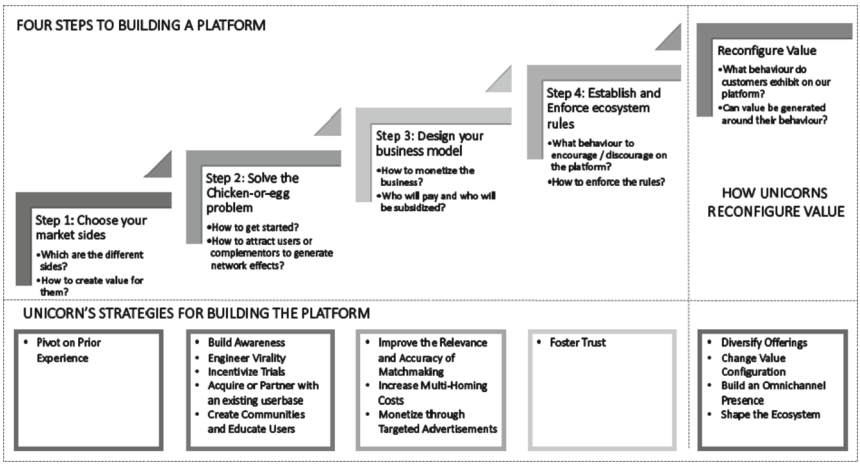

Fig. 1. How Online Platforms Create and Reconfigure value

may entail creating the infrastructure, educating the participants, and even working with regulators. However, doing so prepares the ripe ground for established online platforms to acquire them. Therefore, online platform startups need to build a strong brand before they get acquired.

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Institutional Voids and Digital Ecosystems of India's Public Sector

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Abstract. This study investigates how the idiosyncrasies of the political economy of India interact with the emerging structure of ecosystem economy. The paper argues that the digital ecosystems in India are promoted by the public sector and that they interact closely with institutional voids. It uses theory of ecosystems to conceptualize two digital innovations by India's public sector and investigates how those ecosystems interact with institutional voids. The paper uses discourse analysis to identify the value propositions of the ecosystems and the constraints on their expansion. The analysis shows that while ecosystems may be established to overcome the shortcoming of the market, it is also clear that such institutional voids can impede growth of the ecosystems. The implications of these findings to public policy and business strategies are discussed.

Keywords: Digital Ecosystems · Institutional Voids · Public Sector

1 Introduction

Firms are making unprecedented strategic choices as they undergo digital transformation (Venkatraman 2017). The strategic choices are influenced by the idiosyncrasies of political economy of the country within which the choice is made (Iansiti and Lakhani 2020). The political economies of individual nations are evolving to adapt to the emerging technologies even as they experience inertia of the historical context in which the technologies are embedded. There is little literature on how the specific historical contexts of nations impact the process of digital transformation of the economies. In this article, we draw some insights on the historical context of India, explore its implications on strategic choice of firms investing in India.

Two aspects of India's political economy exemplify the idiosyncrasies of its political economy. First, despite decades of thrust towards privatization, public sector continues to drive the key macroeconomic indicators (Ahluwalia 2019; Khanna 2015). Secondly, the markets of the Indian economy are highly underdeveloped leading to gaps in the institutional infrastructure necessary for Western firms to enter Indian market (Khanna and Palepu 1997). Even as disruptions led by innovations in digital technologies are opening up many opportunities for technology firms and threats for industrial firms, the strategic implications of the disruptive innovations are intertwined with the political

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economy. In India's case, the role played by the public sector in the digital ecosystems and how these ecosystems interact with institutional voids will be the most critical aspects driving strategy and public policy.

Using the idea of ecosystem as the theoretical basis, in this paper we investigate the role of public sector in the ecosystem economy, which is characterized by IT-enabled business ecosystems. A comparison of working of ecosystems in the West to the ecosystems in China shows the ecosystems in the emerging economies interact with the institutional voids in the political economy of the emerging economies (Jacobides 2019; Iansiti and Lakhani 2020). Building on this idea, we investigate two newly emerging digital networks established by the public sector in India. The networks are Open Network of Digital Commerce (ONDC) and Account Aggregator Network (AAN). Specifically, we investigate the discourse around these networks to see how their value proposition interacts with the institutional framework of Indian economy.

Our investigation revealed that while ONDC aims at filling institutional voids, the adoption of AAN is slowed down because of institutional voids. ONDC is established to increase the extremely low adoption of digital commerce in India by focusing on solving the trust issue in digital commerce. However, the discourse on AAN shows that lack of a strong data protection regime can impede adoption of AAN. These preliminary findings provide directions for rigorous research in these lines. Such research can potentially guide digital transformation of firms in India.

2 Theoretical Background

2.1 Ecosystems

Rapid developments in information technology have blurred the boundaries between traditional industries (Mantymaki and Salmela 2017). Traditionally, academics, practitioners and policymakers used clear demarcation of the boundaries between industries based on various parameters such as the markets they operate in and the customers for whom they add value. Establishment of IT-enabled networks to connect various economic units has enabled simultaneous collaboration and competition across industries. For example, while e-commerce firms compete with brick-and-mortar retailers in retail space, some e-commerce firms also provide logistics services to the brick-and-mortar retailers. At the same time, brick-and-mortar retailers share their workforce with e-commerce to help in last mile service delivery including installation and maintenance of complex appliances such as air-conditioners.

Mantymaki and Salmela (2017) argue that the blurring of boundaries between industries creates conceptual difficulties. They argue that some of the older conceptual tools have become inadequate for macro level analysis of competitive environment of a firm. Examples of such concepts include industry, population, cluster, and inter-organizational network. All these concepts assume clear boundaries between firms and industries. The proliferation of recent technologies and the blurring of the boundaries between firms and industries raised many conceptual difficulties especially in studying the collaborative relationships between firms. The concept of ecosystem has emerged as a viable conceptual alternative that captures complexity of the current system.

The idea of ecosystem has its origins in biology. Biological habitats are conceptualized as ecological systems to capture the complexity in the relationship between various animate and inanimate entities and their relationship with the environment. The concept of ecosystem is characterized by its ability to position the whole as greater than the sum of its parts (Jacobides 2019). The concept of ecosystem also encompasses the idea of inter-dependences between entities and the need for collaboration to survive and thrive together in their environment. These characteristics of the concept of an ecosystem prompted business researchers to conceptualize relationships between modern industries as a business ecosystem. While explaining how firms create and design ecosystems, Jacobides (2019 p: 4) describes ecosystem as "an orchestrated network spanning multiple sectors."

Jacobides et al. (2018) identified three different streams of conceptualization of ecosystems. The three streams are business ecosystem stream, innovation ecosystem stream and platform ecosystem stream. These streams differ in terms of the focal unit of analysis and the characteristics of the entities the unit of analysis is connected to in the ecosystem. In the business ecosystem stream, the firm or a new venture is the unit of analysis. The ecosystem is conceptualized as a community of organizations that impact the firm and its operations. In the innovation ecosystem stream, an innovation is the unit of analysis. The ecosystem is conceptualized as the interconnections of upstream and downstream innovations that impact the value proposition of the focal innovation. In the platform ecosystem stream, a platform is the unit of analysis. The ecosystem is conceptualized in terms of the interdependence of the platform sponsor and those that provide network effects inducing complementary products.

For the sake of this study, we conceptualize ecosystem in lines with the platform ecosystem stream. Though the study investigates the role of the public sector, the focus is on ability of the public sector to be sponsor of platforms that connect an array of peripheral firms and individuals who delivery value to and through the platform. The platforms established by the public sector will be the unit of analysis. The ecosystem will be conceptualized in terms of the how these platforms are expected to bring together firms and individuals with offerings that have value proposition to both the platform and other users.

2.2 Ecosystems and the State

Jacobides (2019) argues that ecosystems emerge because of certain structural changes. One of those changes is the removal of regulatory protections within a clear industry boundary. Older regulatory frameworks restricted the range of collaborations between firms to ensure fair competition in the markets. The legal battle between Netscape and Microsoft in the 1990s, often dubbed as the "browser wars" exemplifies this kind of regulatory mechanism and the rationale for such regulation. However, technology-enabled networks of relationships are enabling firms to collaborate in more creative ways even as they compete in different markets. For example, while Samsung competes with Google in the smartphone market, Samsung's smartphones exclusively use Android operating system, despite Samsung having developed its own operating system.

The above relationship between the regulation and ecosystems is observed in the context of Western advanced economies. This contrasts with how ecosystems and the

State interact in the emerging economies. Iansiti and Lakhani (2020) argued that the ecosystem built by the Alibaba group in China fills the institutional voids in the economy. Institutional voids are the gaps in the market mechanisms to support businesses (Khanna and Palepu 1997). E-commerce firms such as Alibaba take up annual sales to increase customer engagement. Alibaba's annual sale is called the 11.11 Singles Day Shopping Festival. The success of such festivals depends on a significantly large number of vendors participating in the festival. The vendors in turn need credit to buy the goods and maintain inventory.

Alibaba observed that there are gaps in access to credit in China. To increase access to credit, it spun off its payment solution into an independent finance firm, Ant Financials. However, without proper regulatory framework and institutions to enforce loan recovery and resolve conflict, the cost of business is too high for Ant Financials. To ensure low cost, Ant Financials built an ecosystem of firms that provided credit rating, AI-enabled underwriting, small loans to vendors, etc. This ecosystem provided an alternative to formal regulatory framework and filled some of the institutional voids in the economy.

In further contrast, the Indian economy, which is also an emerging economy such as China's, did not witness an ecosystem being built around any one firm. While there are a few successful e-commerce/e-logistics firms such as Flipkart, Delhivery, Myntra, etc., none of these companies have created an ecosystem around them yet. The ecosystems in India are localized to narrow range of industries. For example, firms like Swiggy and Zomato have built ecosystems in the restaurant industry. Uber and Ola continue to dominate the ride sharing industry but could not make progress in the restaurant or grocery delivery industries.

While both the West and China are benefitting significantly from the ecosystem economies, India seems to struggle to take advantage of its success in the IT service industry. It is surprising that the country known globally for undergoing structural transformation around the software industry is not able to develop viable software ecosystems neither like in the West or in China. India finds itself in a familiar territory of private sector falling short of delivering required value only for public sector to step in. In this study we look into the current situation where the public sector continues its push to take leadership in digital ecosystems.

2.3 The Role of Public Sector in the Indian Economy

Indian economy has been undergoing structural changes over the last five decades (Ahluwalia 2019). Poverty alleviation programmes started in the early 1980s were primarily driven by policy push towards bringing structural changes to the economy. Prior to these reforms, for over three decades since independence in 1947, India broadly followed the strategy of import substitution through public sector investment in capital goods. The bulk of the technology and capital for the public sector undertakings came from the Soviet Union (Kohli 2006). Although the strategy helped build limited self-reliance of the economy, the average growth rate through the decades remained low around 4% annual growth rate on average. With the population growing at a rapid pace, India experienced sharp rise in poverty levels as well.

Recognizing that the problem is at the structural level, during the 1980s India has initiated structural reforms to the economy. The reforms got impetus in 1991 partially

due to internal issues such as the balance of payment crisis, which depleted foreign currency reserves severely. Geopolitical developments such as the disintegration of the Soviet Union and the Gulf War also expediated the need for structural reforms (Kohli 2006). Under pressure from the International Monetary Fund (IMF) and due to internal compulsions, India took up what is widely referred to as the LPG reforms, an acronym for Liberalization, Privatization and Globalization reforms.

Since 1991, India has embarked on a policy pursuit to lift the restrictions on the private sector in the economy; reduce the footprint of the public sector in the economy; and open the economy to foreign investment, goods, and services. The implementation of these reforms has been gradual with significant resistance from the public and gradual pivot in the final objectives of each of the goals in the LPG reforms (Kohli 2006; Chacko 2018). There is a lot of research that has been keeping track of the policies, their implications, the resistance to change, gradual pivots in the policy objectives and many related topics. Here, we draw attention to one specific reform: the privatization reforms.

Even as early as 1991, privatization, which involves divesting government ownership in public sector enterprises, was planned to happen very gradually (Kohli 2006). Instead of selling the whole public enterprise to private players, the policy facilitated private investment in public sector enterprises leading to partial transfer of ownership. The idea is for the government to retain majority share and management control in the enterprises. Despite a gradual approach towards privatization of public sector enterprises, government had to pause or roll back some of the reforms because of political and electoral compulsions of a democracy still marred by stark income and wealth inequalities. There is widespread skepticism towards free market mechanisms (Chacko 2018).

Commenting on India's pattern of development, Kochhar et al. (2006) observed that India has followed its own growth trajectory as compared to other Asian economies that grew at a comparable rate. They argue that the idiosyncrasies in the India's growth pattern are related to the idiosyncrasies in the policies adopted soon after India's independence. The public sector continued to play a critical role in the economy.

In this research we investigate into the role of public sector in fostering the platform ecosystems in India. The public sector has taken lead in fostering the digital payment ecosystem through Unified Payment Interface (UPI). India has one of most pervasive digital payment ecosystems today. In recent times, experts have been touting the emergence of two other ecosystems as having the potential to transform the economy as effectively as UPI did. These ecosystems are Open Network for Digital Commerce (ONDC) and Account Aggregator Network (AAN). Both these ecosystems are initiated by government-backed agencies.

In the following section, we briefly introduce the objectives, structure and functioning of the two platform ecosystems. We then focus on understanding the value propositions of the platform ecosystems in terms of their interactions with the institutional voids in India's political economy. Specifically, we answer the following research question: How do the digital ecosystems established by India's public sector interact with the institutional voids in India's political economy?

3 Conceptualization of the Focal Ecosystems

In this section, we present a conceptualization of the two initiatives as ecosystems according to Jacobides et al. (2018). The information to do this conceptualization is taken from the websites of the respective initiatives.

3.1 Open Network for Digital Commerce (ONDC)

ONDC declares its objective as "creating an inclusive ecosystem for e-commerce". ONDC is incorporated on 30 December 2021 as a not-for-profit company under the Section 8 of the Companies Act, 2001 by the Department for Promotion of Industry and Internal Trade (DPIIT), Government of India. The investors in ONDC are from both the private and public sector and ONDC is itself incorporated as a not-for-profit private company.

The ONDC network is built on open protocols like the hypertext protocols that facilitate information exchange over the internet. The network is designed as a technology solution that allows for platform/application-agnostic access to the market. Individuals and businesses can register to join either the seller network or the buyer network or both the networks. The registered user gets access to the other side of the market across different digital platforms that are interoperable on the ONDC's network.

ONDC is expected to democratize digital commerce and expand the coverage of digital commerce. It is estimated that the gross merchandise value (GMV) for digital commerce in India is about 4.3% of the total GMV of the retail sector. This is considered as extremely low in comparison to countries like China, Korean, UK etc., where the digital commerce accounts for around 25% of the total retail GMV.

The limitations in the reach of the digital infrastructure in India is seen as the reason for the low utilization of the digital channels for commerce. Building infrastructure is seen as the responsibility of the government and the public sector. One option to take corrective measures is building a platform developed and maintained by the government. However, the government has identified some limitations of the platforms.

Platforms provide integrated solutions, including warehousing, logistics and payments solutions, to enable commerce. However, new sellers find their competitiveness limited unless they are part of an end-to-end service provider. Secondly, as the platform grows and the number of sellers increases, discretionary behavior might emerge as the platform provider would find it more profitable to not coordinate but to compete with the sellers.

A more important limitation of a single platform is the portability of capabilities. One of the biggest advantages of platforms in e-commerce is that the users are embedded in the platform and build reputation over time. The reputation metrics are usually transparent to the other side of the platform and solve the problem of trust in online transactions. For example, drivers with long term association with Uber have reputation measured in terms of number of rides taken and the average customer ratings. These metrics help customers engage in the transaction with the trust that the service provider will deliver the promised value. The problem with partnering with one large platform is that these reputation metrics are not portable from one platform to another.

Keeping in view these problems, the DPIIT established ONDC to implement a set of communication protocols that connect different inter-operable platforms. Users on either side of these platforms may register to use the network to access users on other platforms in addition to those on the platform on which they are present. Applying the theoretical framework of Jacobides et al. (2018) we can see that ONDC is a innovation and platform ecosystem at the same time. It is a digital innovation that connects various platforms in one large network. The value proposition depends on innovations both by the platforms and the users who subscribe to the network through these platforms. The DIPP is using ONDC to create a network of enterprises and individuals to increase welfare of citizens. ONDC is essentially a technological solution governed to maximize value to the providers of all the complements.

3.2 Account Aggregator Network (AAN)

Account Aggregator (AA) is a licensed non-banking financial institution company (NBFC). Account Aggregators provide a consolidated view of an individual's financial information to the Financial Information Users (FIU). Any lender or insurer can be a FIU. The idea of consolidating financial information of users has been around for two decades (Agrawal et al. 2004). However, the technology proposed in the earlier forms of aggregation of financial information was replete with security concerns, which would have put insurmountable regulatory checks against aggregators.

Rapid advancement in digital technologies has now made aggregation of financial information more secure. Account Aggregators now provide their service via applications that can be installed on smartphones. The Account Aggregator acts as a consent manager to facilitate flow of information from Financial Information Provider (FIP), such as bank with savings account of the user, to the Financial Information User (FIU). The AA provides the backend technology that uses Application Programmer Interface (API) technology to establish conduits of information between the FIP and FIU. The customer, whose financial information is of focal interest, interfaces with the AA through a mobile application. The interface between the customer and the AA allows the user to give consent to share specific information residing in the FIP's database to the FIU.

The Reserve Bank of India has currently provided NBFC-AA license to 12 AAs. It is estimated that this number could go up to 17 very soon. Many financial institutions have already started taking the services of AAs and the number of consents given for transfer of financial information is already in the six figures. The policy makers have realized the need for building an AA ecosystem that allows for smooth flow of financial information and further expansion of access to formal credit. The proposed Account Aggregator Network (AAN) is expected to facilitate this flow of information.

Just like ONDC, AAN is implemented as set of technology standards to facilitate safe exchange of financial information. It is an innovation whose value proposition is critically linked to both upstream and downstream innovations. RBI plans to use the network to orchestrate secure conduits of financial information to increase transparency and improve meaningful financial inclusion in the economy. According to Jacobides et al. (2018), AAN can conceived as an ecosystem by both innovation and platform ecosystem streams.

4 Ecosystems and Institutional Voids

In this section, we conduct an empirical investigate how the value proposition of the two ecosystems interact with the institutional voids. We specifically study the discourse on the value proposition of these ecosystems to understand how the ecosystem fills the gaps or is affected adversely by the gaps.

The study uses discourse analysis to analyze the text in the consultation papers and regulations on these ecosystems. Discourse is a way of signifying multiple points of view on an issue (Fairclough 1993). Discourse analysis provides a way to unearth the linguistic patterns in a text, thereby bringing forth the discourse participants motives and strategies. The final product of the discourse analysis provides us a way to unearth the dialectics between the discourse and the object of the discourse (Gill 2000).

Discourse analysis when applied in the context of development of a technology artifact, provides a way to conceptualize the final, acceptable technology artifact through the study of the text in the discourse that accompanies the development of the artifact (Gill 2000). This study aims at understanding the role of ONDC by analyzing the discourse around its development. One of the by-products of analyzing the accompanying discourse is the unearthing of the factors that aid the development of the technology or hinder its development. This study uses discourse analysis to study the guidelines of AAN that are still under deliberation to unearth the institutional gaps that need to be filled for AAN to become a reality.

4.1 Data

Role of ONDC. To understand the role of ONDC, we reviewed the public consultation paper published on the website in January 2022 and a strategy document accompanying it.

Deliberations on AAN. The basic institutional framework for the AAN is provided by the Reserve Bank of India through its Master Direction first published in 2016. This document is constantly being updated based on the inputs from the stakeholders. The key stakeholders of the AAN have organized as an industry alliance formally registered as a not-for-profit private limited company. In this research we use the provisions of RBI's Master Direction and the stakeholder comments on specific provisions to arrive at some consolidated insights into the key regulator questions concerning AAN.

4.2 Analysis and Findings

Enabling Digital Commerce and Ensuring Trust. The consultation paper on the role of ONDC is analyzed to identify its objectives. Specifically, we did a topic modelling of sentences in the 35-page strategy document available on their website. The Latent Dirichlet Allocation (LDA) model is used to categorize the sentences in the document into five topics. LDA takes number of topics as a hyperparameter.

The strategy paper is available in PDF format. We downloaded the paper and converted it into a text file using Python. We then manually removed text from the title page and the pages containing references and appendices. The clean text file is read and

cleaned further to ensure that text is not broken into lines as is normally the case with text read from PDF files. The text is then tokenized into sentences. Each sentence is now considered a document in the corpus for topic modelling. There are 668 sentences in the corpus.

The hyperparameter for topic modelling using LDA is the number of topics, which is set at 5. Table 1 shows the five topics, the ten most frequent words in these topics and the number of sentences classified under this topic. One observation that is relevant is the presence of the word "trust" in four out of five topics covering close to 90% of the document. Other interesting terms are "cancellations" in Topic 2 and "grievance" in Topic 3. Though a firm assertion needs expansion of scope of the study and rigorous evaluation of the modelling, the current observations indicate that ONDC is being developed to mitigate the lack of trust in the existing online e-commerce markets. This case shows that the networks are built to fill institutional voids.

Table 1. Words representing each topic and the frequency of topics.

Topic	High Frequency Words	Number of sentences
Topic 1	Network ondc participants sellers trust issues buyer search order place	151
Topic 2	issues commerce proposed refunds returns trust cancellations sellers delivery practices	87
Topic 3	trust product platform seller ondc buyer resolution sellers grievance central	99
Topic 4	commerce ondc seller network process greater value entities buyer sellers	61
Topic 5	buyer seller ondc network app terms trust logistics sellers commerce	270

Data Protection as a Necessary Condition for the Digital Ecosystem. There are 120 guidelines identified by the key stakeholders in AAN. These 120 are further classified under 25 different heads with different number of guidelines under each head. These guidelines are in difference stages of deliberation with a few of them finalized by the stakeholders. We designed a metric to quantify the ease of finalizing guidelines under each of the 25 heads. The difference-sum ratio is calculated as the ratio of difference between finalized and deliberated guidelines in the numerator and the sum of the two in denominator. This value can range between -1 and $+1$. The closer it is to -1, the greater the number of guidelines under deliberation in comparison to guidelines finalized. It is the opposite if it is $+1$. The value of -1 indicates that none of the guidelines under this are finalized.

Purpose codes, recurring consent management and SLAs (Service Level Agreements) are categories of guidelines in which none of the guidelines are finalized. All are being deliberated. On the other hand, all the guidelines are finalized under the categories

technical interoperability, central registry, and token issuance service, and LSP (Lending Service Provider) implementation.

The above ratio provides a way to measure the extent to which a specific set of guidelines are contentious. To get further clarity on the differentiation between the contentious and non-contentious guidelines, we further consolidated these 25 categories into four categories: technical implementation, data management, financial regulation, and commercial details.

Guidelines are coded under technical implementation if they involve how the technological backbone of the ecosystem is built. For example, there are guidelines that mention which API specification is being used in the currently live ecosystem. Guidelines are coded under data management if they deal with data protection and privacy. For example, there are guidelines that state whether multiple financial services can be tied to one consent artifact.

Guidelines coded under financial regulation deal with the adaptation of the principles of financial regulation in the physical world to the digital context. For example, there are guidelines that concern the registration of legal entity in the AAN as virtual user and if one user can get multiple virtual user addresses. Guidelines coded under commercial details deal with compensation for different stakeholders for the service in AAN. For example, there are guidelines on the pricing model that the AAs are expected to follow.

These four categories are arrived at through discourse analysis. Each guideline is carefully read to interpret the intention of keeping the guideline. Based on the interpreted intent, the first round of coding is done to categorize the guidelines. The process is repeated till we arrived at the bare minimum number of categories by clubbing categories together in each iteration until the categories are conceptually disparate. In the case of this data, we had to go through three iterations of coding before arriving at these four categories.

Table 2. Number of heads and extent of deliberation under each category.

Heading level	Example	Font size and style
Technical Implementation	6	0.6
Data Management	8	−0.4
Financial Regulation	8	−0.1
Commercial Details	3	−0.1

Table 2 shows the average values of the difference-sum ratios under each category. We can see that the guidelines under the technology implementation guidelines are most easily finalized. The most deliberated are the guidelines under data management. These two can be intuitively understood. The technology implementation aspects are usually clarified even before the implementation begins. It is no surprise that most of these are already finalized. On the other hand, there is no specialized data protection regulation

operational in India currently. Therefore, there are concerns about data protection. Interestingly, most of the guidelines related to financial regulations and commercial details are also under deliberation.

The results of this analysis indicate that for the Account Aggregator Network to get more access, there needs to be a strong data protection regime to clarify questions regarding data management. In the absence of adequate institutional framework for data protection, the guidelines on the AAN will not be finalized easily leading to slow adoption of the network. This case shows that institutional voids can hamper the emergence of ecosystem economy in India.

5 Implications and Conclusion

India continues to be an expanding market for global firms. Changing technology landscape has pushed all the firms to consider largescale transformations broadly referred to as digital transformation. One of the key decisions to make in the digital transformation is to decide whether to be an orchestrator or just participate in specific ecosystems (Venkatraman 2017). Davidson et al. (2015) classified ecosystems into four kinds based on complexity and degree of orchestration. Given that public sector is actively building ecosystems to bridge institutional gaps, the ecosystem is going to span across industries and the government would tend towards having tight control over the network. Davidson et al. (2015) calls this kind of ecosystems as the Lion's Pride type of ecosystems. In such ecosystems the entry barrier is low, but it is critical to have strategic alignment with the strategy of the orchestrator.

Accordingly, it is critical for global firms investing in India to realize that despite their dominance in the global markets, they may not be able to orchestrate ecosystems in India. While the public sector orchestrates critical ecosystems in India, it is important for participating firms in the ecosystem to align their strategy with the governments objectives – building trust in digital commerce and expanding the reach of digital commerce in India. At the same time, our analysis also informs the policymakers of the importance of developing regulatory mechanisms to fill in institutional voids that can hamper adoption of digital ecosystems. Specifically, in order to promote financial inclusion through digital networks, it is critical that a strong data protection regime is in place.

5.1 Limitations and Future Work

This article presents initial observations on the discourse around two of the emerging digital ecosystems in India. The analysis of the discourse needs to be more rigorously done to test the strength of the claims made in the paper. Most of the claims in the discussion and implications are made based on the initial results and broad understanding of the arguments being made in academic and practitioner literature. In the future work, we intend to dig deeper into the literature on ecosystem economy and digital transformation to reformulate a more focused research question. Based on the revised research question, we intend to design a more rigorous content and discourse analysis of the public discourse around ecosystems in India.

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How Social Media Marketing Enhances Brand Communities Engagement: Developing an Integrated Model Using S-O-R Paradigm

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Abstract. The purpose of this study is to investigate the various dimensions that lead to the enhancement of brand community engagement. Furthermore, the study intends to investigate the indirect relationship between social media marketing activities and brand community engagement by investigating the parallel mediating roles of information quality, system quality, and service quality, ultimately influencing brand loyalty. A purposive sampling technique was used to collect the data from individuals actively involved in following brand community of various brands on social media. The data was collected using a structured questionnaire, and the analysis was carried out using structural equation modelling in SPSS 20 and AMOS 22. The outcomes of the study demonstrated a substantial relationship between social media marketing activities, information quality, system quality, service quality, brand community engagement, and brand loyalty. Furthermore, the study discovered a significant parallel mediation effect, revealing the indirect impact between social media marketing activities and brand community engagement. Lastly, the study's findings and their implications are thoroughly evaluated.

Keywords: Online brand community · social media marketing activities · brand community engagement · brand loyalty

1 Introduction

The past decade has led to proliferation of online avenues and exponential growth of social media. Brands are taking advantage of this modern era of digital communication to broaden their geographical coverage and enhance brand evaluation among their customer base [1]. Customers on the other hand are gradually gaining authority to regulate their interaction with the brand. Social media has reshaped simple dyadic interactions and surpassed conventional media by engaging customers, making connections, and establishing long-term relationships [2]. In marketing literature, the effort to enhance and sustain customer engagement, building online brand communities and personalizing individual's experience is a key aspect [3]. Thus, marketers' objectives expanded from relationship marketing to engaging clients in all possible ways [4].

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An online brand community is a virtual space where people with common interest or passion for a particular brand can engage, interact, and form connections [5]. Such communities mostly operate through digital platforms such as social media, websites, forums discussions, etc. building relationships among like-minded members [6]. These online communities provide a great platform for businesses to accumulate feedback, collaborate with members, and leverage user-generated content. In return, brands provide members additional perks, strengthening a sense of belonging and worth, therefore playing an essential part in enhancing brand loyalty [5, 7].

Online brand communities (OBCs) have been identified as a significant arena for fostering and monitoring brand community engagement (BCE). Online BCE is the powerful inherent motive that drives connection among members with an OBCs [8]. Members of the OBCs are people who track all activities on social media, promote brand's offerings and content with others, and enjoy viewing everything a brand does. For instance, these OBCs members can not only receive brand related material, but they can actively contribute to its creation [5]. Hence, for multimodal communication and productive social community networking most of the OBCs are built on social media [9].

Considering growing recognition of the vitality of online brand communities in marketing literature, there still exists a compelling requirement to explore various aspects of BCE [10–12]. Moreover,the study identifies a notable research gap in the intricate relationships involving social media marketing activities (SMMA) and their associations with information quality (InfoQ), system quality (SysQ), and service quality (SQ). Existing studies have independently explored aspects of SMMA [13], as well as InfoQ [14], SysQ [14], and SQ [15] in various online context. Despite these individual examinations, there remains a scarcity of comprehensive investigations into the interplay among these elements. For instance, Fetais [16] delved into the impact of SMMA on brand community engagement (BCE). Naqvi [14], investigate the influence of InfoQ and SysQ of e-brand communities on customer engagement. Our study aims to explore the intricate relationships among these dimensions, offering a more comprehensive perspective on how SMMA influences information, system, and service quality.

Thus, in response to this gap the study develops and integrated framework incorporating stimulus-organism-response paradigm (S-O-R) for managing engagement in online brand communities. By utilizing S-O-R theory as our framework, we aim to provide a more comprehensive understanding of the factors that influence brand community engagement and how companies can effectively use social media marketing activities to engage with their customers. The research aims to investigate the indirect parallel mediation effect of InfoQ, SysQ and SQ on the relationship between SMMA and BCE in an OBC. Subsequently, examining the relationship between BCE and brand loyalty (BL).

Such insights can inform managers of relevant brands about whether they need to consider InfoQ, SysQ and SQ in their social media marketing activities to maximize brand community engagement. Marketers are advised to focus on providing general and exclusive information related to new products and promotions, addressing service factors like effective problem-solving and responsiveness, and considering system factors for optimal performance [17]. Second, this study is among the first to discuss quality context in the domains of social media marketing activities and brand community engagement.

Therefore, it provides an initial understanding of engagement optimization in online brand communities.

2 Theoretical Background

2.1 Stimulus-Organism-Response

The research incorporates Mehrabian and Russell's [18], Stimulus-Organism-Response (SOR) theory, which is critical in constructing the study's conceptual framework. Stimulus pertains to sensory and cognitive inputs that users encounter while dealing with brand online, encompassing user experiences, emotional connection, sense of belonging, social influence, visual design, etc. In the virtual realm, the stimulus serves as the foundation of online brand communities, and how its features shape the customer's attitude towards the brand [14]. The present study considers social media marketing activities [19, 20], information quality [21], system quality [22] and service quality [22] of an online brand community as the stimuli attributes that holds substantial influence over engagement within online brand community.

Subsequently, the organism dimension includes information and thought processing, with users responding to environmental cues or stimuli [23]. It includes all the processes between inputs and consumer responses, including thoughts, perceptions, emotions, and experiences [24]. The organism in the current study represents the level of customer engagement with the brand community [20–22]. It includes consumers' interaction, involvement with other members and their overall perception of a brand within an online brand community.

Response is the outcome behavior that an organism (individual) exhibit's reaction to a stimulus. Consumer response to stimuli is divided into approach and avoidance [25]. Approach indicates the user's willingness to actively engage in an online brand community, whereas avoidance signifies the user's decision not to get involved with the brand community. In this specific study, brand loyalty is depicted as the response, indicating the user's intention to make repeat purchases [19, 20]. In the context of BCE, user behaviour goes beyond recurrent decisions to include a favorable internal perception and affinity for the brand.

In essence, the SOR theory assists us in understanding that customer's response to environmental stimuli is not a one-way reaction. It's a complex interplay between the stimulus, the user's internal processes intervening between the inputs and their final response [26]. Therefore, the intent of the research is to validate BCE, and this theory provides a solid theoretical foundation by understanding how external stimuli can influence individuals' inner cognitive and emotional factors, forming their responses and behaviours in the context of online brand communities.

2.2 Brand Community Engagement (BCE)

"Community engagement encompasses customers' altruistic behaviours towards fellow members, active participation in collective activities, and voluntary contributions to community-endorsed initiatives aimed at enhancing shared value for both oneself and

others" [27, p. 66]. Brand community engagement is an important platform for firms to strengthen their point of difference and competitive position by deepening consumer ties and engaging them in collaborative brand-building. Brand community engagement differs from ordinary actions such as "joining" or "liking" a brand page [28]. It goes beyond these initial steps, indicating a purposeful involvement by customers to engage with fellow community members [6]. Furthermore, community participation is linked to beneficial community behaviours such as assisting other members of the community, participating in cooperative activities for mutual benefit, and organizing offline events among members [29]. Additionally, individuals who strongly identify with a brand and actively engage with it are found to experience elevated positive emotions and potent effects triggered by specific emotions [30].

2.3 Literature Review and Hypotheses Development

Social media is considered one of the most vital marketing mediums to communicate brand information since its interactive attributes enable participatory, collaborative, and knowledge-sharing activities [31]. Brands regularly engage with their customers through social media marketing activities (SMMA) to captivate their attention and affection [32]. They increasingly employ SMMA as their major marketing strategy to build brand trust, brand loyalty, consumer-brand relationships, and purchase intention [33]. Inextricably linked to BCE, social media marketing is referred to as "a process by which companies create, communicate, and deliver online marketing offerings via social media platforms to build and maintain stakeholder relationships that enhance stakeholders' value by facilitating interaction, information sharing, offering personalized purchase recommendations, and word of mouth creation amongst stakeholders about existing and trending products and services" [34, p. 1296]. Studies on social media marketing incorporate multiple elements to evaluate it. Kim and Ko [35], considered trendiness, entertainment, interactivity, word of mouth, customization as drivers of SMM in the luxury brand business. Similarly, Yadav and Rahaman [34], also used five key elements to measure social media marketing in e-commerce industry i.e., interactivity, trendiness, word of mouth, informativeness, and personalization. The present study conceptualizes SMM as a multidimensional construct along with the extant literature [36, 37]. Accordingly, marketers should focus on those SMMA that deliver sensory stimulation to customers for creating competitive advantage, long-lasting impression, emotional connection [38].

Social media marketing heavily relies on social media content [1], it is crucial to comprehend the characteristics of this content that motivates BCE to achieve brand loyalty. Successful SMMA prioritizes the development of genuine, credible and valuable information in order to build trust and cultivate loyalty among users [39]. However, most of the information shared is user generated creating a dynamic and diverse information landscape [40]. While consumers are inclined to engage with the posted content, there is a possibility of misinformation spreading [41, 42]. As a result, a persuasive case can be made for brands to take innovative methods to social media marketing, assuring the dissemination of information that not only captivates but also connects with customers inside online brand communities. This strategy seeks to encourage meaningful engagement, authentic connections, and, eventually, brand loyalty.

H1: Social media marketing activities positively affect information quality.

Furthermore, with the advancement of social media, brands with great system features such as user-friendly interface, sound interactivity and design may assist in attracting users while fostering brand loyalty and customer engagement [43]. Social media marketing activities frequently accentuate user-centric features and functionalities [44]. Simple, concise, and useful information assisted users in smoothly navigating the system enhancing system usability.

H2: Social media marketing activities positively affect system quality.

E-service quality refers to "the extent to which online websites improve the efficiency and effectiveness of customers' browsing and consumption, including service links such as distribution and consultation" [45]. Furthermore, social media marketing has a considerable impact on the quality of a brand's service. It is widely acknowledged as a requirement for customer perception and experience [46]. Interaction in OBCs enables user engagement through interactive content and contests, generating more personalized and enjoyable experience. Moreover, services are tailored to match current trends, technology, and user behavior, resulting in customer engagement. Brands can enhance their service by addressing user suggestions, rectifying their issues related to delivery, returns, refunds.

H3: Social media marketing activities positively affect service quality.

Information quality (InfoQ) assesses customer expectation and perceptions regarding the information disseminated by the brand [24]. In a digital space it is interpreted as "user's perception of the quality of information presented on website" [47, p. 299]. The technical characteristic of InfoQ includes accuracy, up to date and sufficiency [48], of the information offered by brands on products and services via OBCs. Based on existing literature, users also find certain characteristics of InfoQ which further includes content quality, format interactivity, data accessibility, completeness, and consistency [49, 50]. Information with high content quality and personalized information in the online brand communities stimulate experience and emotional resonance among users, allowing the formation of unique user groups with commonalities and building of long-term relationships with brand [38]. Studies suggested there is a significant relationship between InfoQ and BCE [14, 24].

H4: Information quality positively affects brand community engagement.

System quality is the user's assessment of the operational efficiency of system features. In the online setting SysQ was adopted to measure ease, bug free, performance, customer-friendly response time of information system [51], all these aspects improve online user experiences. Users' opinions in OBCs are influenced by issues encountered throughout the online purchase process (e.g., difficulties with shipment, return, refund, or exchange). Customers perceive a system to be more effective when it is less complex and as a result, they are more inclined to recall and recognize the brand [52]. They expect swift accessibility, log-on, search/browse, and webpages downloading [50], therefore performance of brand is determined by the quality of its website. Jang [53], characterized SysQ as a fast and simple exploration of information within the community.

Subsequently, it is essential to assess the magnitude to which system quality influences BCE. In many earlier studies, system quality was considered a critical factor influencing customer engagement in OBCs [14, 24, 54].

H5: System quality positively affects brand community engagement.

In the marketing literature, service quality often reflects customer perceptions and value-judgement of a product or service [55]. It is the level to which a user evaluates the service provider's assistance and services delivered through the online platform in terms of swiftness, authenticity, and empathy [56]. It is the value-added attribute of marketers since it possesses firms' credibility and legitimacy which subsequently increases customers' response towards the brand. Roy [57], have highlighted that favorable reviews of service quality upgrades firms-customer relationship quality and is thus likely to elicit customer engagement behaviors in online brand communities. Prior studies have attempted to explain how service quality is connected to customer engagement [58–60]. Added to that, according to Chang [61], customer engagement indirectly influences satisfaction and word of mouth through service quality in healthcare industry. SQ has been identified as a significant predictor of customer engagement [54, 62]. Additionally, it has been noted as an important factor between the relationship between customer experience and engagement [63] in online brand communities.

H6: Service quality positively affects brand community engagement.

InfoQ, SysQ and SQ are major elements that determine customer attitude towards the technology they use. Customers engaging in online brand communities are more likely to employ the entire spectrum of engaging options to create their own online experience if they believe perceived quality (InfoQ, SysQ, SQ) is good [64]. With higher perceived quality customers are more inclined towards the brand and are more likely to interact with members of OBCs. Each of the perceived quality (InfoQ, SysQ, SQ) has been widely acknowledged as strong predictor user/customer satisfaction and experience which elevates emotional connection (i.e., customer engagement) with the brand [63] consequently leads to loyalty in OBCs. Busalim [50], conducted a systematic literature review and confirmed that InfoQ, SysQ and SQ encourage users to continue use the online platform for social interaction. Accordingly, we argue that when a customer has better perceived InfoQ, SysQ and SQ, it means he/she would have an intention to be engaged with the brand in OBCs.

H7: Information quality mediates the effect of social media marketing activities on brand community engagement.
H8: System quality mediates the effect of social media marketing activities on brand community engagement.
H9: Service quality mediates the effect of social media marketing activities on brand community engagement.

In OBCs context, BCE reflects the intrinsic motivation of community members to interact and communicate with members [65]. An essential consequence of BCE is brand loyalty [14]. Studies have demonstrated correlation between brand loyalty and BCE in context to luxury fashion brands [16]. Furthermore, the strong correlation of loyalty with customer engagement was verified by a review paper [14]. More pertinent to present

research context, there exists a positive correlation between BCE and brand loyalty within the facebook brand communities [67], social media brand communities [68], tourism social media [69], online hotel brand community [70]. Moreover, within the context of OBCs customer engagement is the strong predictor brand loyalty [24]. Furthermore, it is found that relationship commitment and customer satisfaction influences loyalty intention to use the online brand community [38]. Therefore, it is anticipated that in an OBC, an individual's assessment of InfoQ, SysQ, and SQ can facilitate BCE and consequently increase brand loyalty.

H10: Brand community engagement positively affects brand loyalty (Fig. 1).

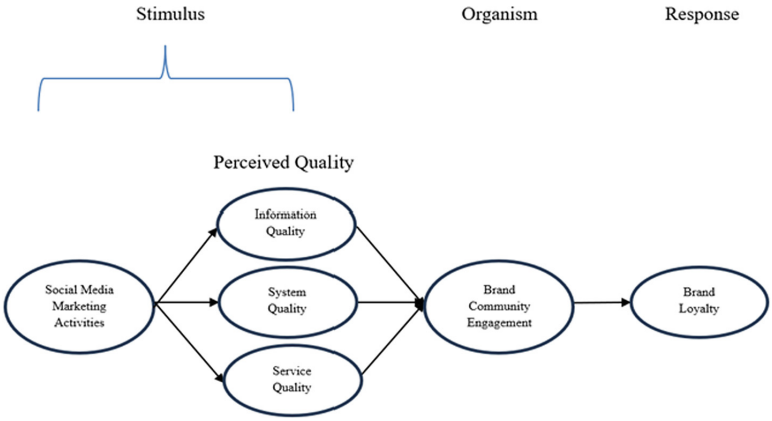

Fig. 1. Proposed Research Model [14, 24]

3 Methodology

3.1 Procedure and Sample

In this study, a purposive sampling approach was employed to gather data. It was used to improve the sample's congruence with the research's aims and objectives, hence increasing the research's quality and the credibility associated with both the data gathering method and the resultant conclusions [71]. The selected participants bring forth relevant insights and experiences directly related to the phenomena under investigation, possessing firsthand knowledge of the social media marketing activities employed by brands within online brand communities. A thoroughly prepared questionnaire was developed utilizing validated and widely recognized scales to examine every aspect of the research model. The target population for data collection was individuals actively following the brand community of various brands on social media. A total data of 247 respondents was collected. However, ten of these questionnaires were incomplete and were thus omitted from further analysis. Therefore, 237 usable questionnaires were thoroughly examined for further investigation in the study.

The study drew on a diverse sample of respondents to provide comprehensive insights into the topic. Table 1 summarizes the participant profile, which includes a wide range of demographic variables. The gender breakdown of respondents revealed a slight majority of males (58.2%) versus females (41.8%). Participants ranged in age from 18 to 25, with 64.6% aged 25 to 30, 27.4% aged more than 30 with 8%. The respondents' educational background varied with notable presentation across postgraduate and above with 49.4%, followed by graduate (27.4%) and intermediate (23.2%). Further, the annual income of participants revealed income less than 5 lakh with 49.4%, income between 5–10 lakh with 27%, and income above ten lakhs with 23.6%.

Table 1. Demographic profile

Sno.	Variable	Categories	Frequency	Percentage%
1	Gender	Male	138	58.2
		Female	99	41.8
2	Age	18–25	153	64.6
		25–30	65	27.4
		More than 30	19	8
3	Marital Status	Married	23	9.7
		Unmarried	214	90.3
4	Education	Intermediate	55	23.2
		Graduate	65	27.4
		PG and above	117	49.4
5	Annual Income	Less than 5 Lakh	117	49.4
		5–10 Lakh	64	27
		Above 10 lakhs	56	23.6

3.2 Measures

Pilot tests were carried out to finalize scale items, involving a thorough discussion of a comprehensive list of items related to SMMA, InfoQ, SysQ, SQ, BCE, and BL with 30 respondents. The objective was to assess the relevance and quality of these items. Based on the feedback received, certain items were modified. Throughout this process, adjustments were made to the language of a few items within the IQ and SMMA constructs, addressing issues of repetitiveness. The measurement scales employed in this study were sourced from existing literature. The questionnaire comprised three sections. The initial section focused on gathering preliminary information from respondents. These initial questions encompassed inquiries such as "Do you follow social media brand community pages?", "Do you purchase from social media brand community page?" and "How frequently do you purchase through social media brand community page?". This section

assisted in establishing the foundation for understanding respondents' involvement with online brand communities on social media.

The subsequent section comprised items assessing the primary concepts using a five-point Likert scale, ranging from 1, indicating "strongly disagree," to 5, signifying "strongly agree." A Likert scale was employed to assess attitudes by allowing respondents to express both the intensity and direction of their opinions on a given topic [72, 73]. The construct of social media marketing activities was measured by employing scales adapted from Ismail [73]. For information, system, and service quality, three-item scales were adopted from Aboelmaged [48]. Brand community engagement was evaluated using items adapted from Algesheimer [65]. As the dependent variable, brand loyalty was measured using questions adapted from Alwaidi [74]. Finally, demographic information was collected to provide contextual background to the responses.

4 Data Analysis

To evaluate the hypotheses, a two-step maximum likelihood method employing structural equation modelling by using IBM SPSS 20.0 and AMOS 22 was implemented Anderson and Gerbing [75]. SPSS serves for initial data analysis and demographic profiling, whereas AMOS, an extension within SPSS, is employed for intricate structural equation modeling. To begin, with the help of confirmatory factor analysis (CFA), convergent and discriminant validity of the model were calculated. The research model was assessed in the second phase, and the proposed hypotheses were tested using path analysis. The following section provides a detailed description of the study analysis procedures. Further, parallel mediation was performed using AMOS 22 to examine the indirect relationship [76].

4.1 Measurement Model

We estimated model fit, internal consistency, and validity through confirmatory factor analysis (CFA) [75]. Our CFA results suggest the model's good fit of the data: chi square = 343.210, CMIN/df (minimum discrepancy divided by degree of freedom) = 1.972, CFI (comparative fit index) = 0.962, GFI (goodness of fit index) = 0.880, AGFI (adjusted goodness of fit index) = 0.841, RMSEA (root mean square error approximation) = 0.064, SRMR (standardized root mean residual) = 0.036. Furthermore, to assess the internal consistency, we inspected composite reliability (CR) and observed that all the composite reliability values were above the threshold limit, i.e., 0.7 [77]. The loadings for all the items were found to be significant, and no item was dropped. Finally, the study examined the discriminant validity where the square root of the average variance (AVE) extracted was greater than the correlation between each construct pair [78]. Therefore, based on the goodness of fit criteria, we found that the measurement model has a good fit model (see Table 2).

4.2 Structural Model (Path Analysis)

The hypotheses testing results are shown in Table 3. The results shows that SMMA exhibits favorable effect on InfoQ (H1; estimates = 0.827, S.E. = .061, $p < 0.001$),

Table 2. Reliability and Validity

	CR	AVE	BL	SMMA	SQ	InfoQ	SysQ	BCE
BL	0.914	0.728	**0.853**					
SMMA	0.922	0.746	0.755	**0.864**				
SQ	0.901	0.751	0.716	0.766	**0.867**			
InfoQ	0.887	0.724	0.742	0.828	0.795	**0.851**		
SysQ	0.886	0.723	0.727	0.839	0.799	0.823	**0.850**	
BCE	0.915	0.729	0.766	0.784	0.776	0.770	0.762	**0.854**

SysQ (H2; estimates = 0.893, S.E. = .061, $p < 0.001$), SQ (H3; estimates = 0.734, S.E. = .057, $p < 0.001$). Subsequently, InfoQ (H4; estimates = 0.315, S.E. = 0.081, $p < 0.001$), SysQ (H5; estimates = 0.234, S.E. = 0.074, $p < 0.001$) and SQ (H6; estimates = 0.367, S.E. = 0.077, $p < 0.001$) has favorable effect on BCE respectively. Therefore, H1, H2, H3, H4, H6 were empirically supported. In addition, BCE has a positive effect on BL (H10; estimates = 0.858, S.E. = 0.068, $p < 0.001$). Thus, the empirical evidence supports the hypotheses.

Table 3. Path analysis

		Estimate	S.E.	C.R.	Std. Estimate	P	Results
H1	SMMA → InfoQ	0.827	.061	13.543	.873	***	Significant
H2	SMMA → SysQ	0.893	.061	14.684	.879	***	Significant
H3	SMMA → SQ	0.734	.057	12.923	.819	***	Significant
H4	InfoQ → BCE	0.315	.081	3.875	.326	***	Significant
H5	SysQ → BCE	0.234	.074	3.172	.260	.002	Significant
H6	SQ → BCE	0.367	.077	4.775	.360	***	Significant
H10	BCE → BL	0.858	.068	12.697	.798	***	Significant

4.3 Parallel Mediation Analysis

A structural analysis employing structural equation modeling was performed to investigate the hypothesized parallel mediation analysis in AMOS 22. The approach utilizes a bias-corrected bootstrapping procedure with a 95 percent confidence interval (CI), drawing 5,000 bootstrap samples from the dataset. The results of the analysis are summarized in Table 4.

The parallel mediation model was used to investigate the mediation effects of InfoQ, SysQ and SQ between SMMA and BCE. The mediation relationship was accepted

Table 4. Parallel mediation analysis

		Estimate	Lower	Upper	p value
H7	InfoQ	.261	.093	.490	.004
H8	SysQ	.209	.016	.416	.038
H9	SQ	.270	.093	.538	.001

when the lower and upper bound of the bootstrap CI of the indirect effects did not include zero (Preacher and Hayes, 2004). The estimated indirect effect of each mediator, represented by its respective path coefficient, conveys details on the strength and direction of the mediation. The analysis revealed significant indirect mediation effects for all three variables, InfoQ (estimates = 0.261, LLCI = 0.093, ULCI = 0.490, $p < 0.05$), SysQ (estimates = 0.209, LLCI = 0.016, ULCI = 0.416, $p < 0.05$), and SQ (estimates = 0.270, LLCI = 0.093, ULCI = 0.538, $p < 0.05$). Therefore, all three variables, InfoQ, SysQ and SQ demonstrated statistically significant mediation effects.

5 Discussions

The research highlights the different dimensions of brand community engagement. Furthermore, the study also investigates the indirect relationship between social media marketing activities and brand community engagement (through information quality, system quality and service quality). The results indicate significant links within the model. The computed path coefficients show the intensity and direction of the correlations between the variables.

The paths from social media marketing activities to information quality, system quality and service quality shows highly significant relation (SMMA → InfoQ: $\beta = 0.827$, $p < 0.001$; SMMA → SysQ: $\beta = 0.893$, $p < 0.001$; SMMA → SQ: $\beta = 0.734$, $p < 0.001$). This indicates that social media marketing activities have a significant positive influence on these dimensions of online brand communities. Brands that use social media marketing activities effectively can convey reliable and pertinent data (InfoQ), improve opinions of users about system efficiency (SysQ) and acquire reputation for excellent service (SQ), Thereby, encouraging positive environment within the online brand community.

In addition, it was found that information quality, system quality and service quality have a significant relation with brand community engagement (InfoQ → BCE: $\beta = 0.734$, $p < 0.001$; SysQ → BCE: $\beta = 0.234$, $p = 0.002$; SQ → BCE: $\beta = 0.367$, $p < 0.001$). The positive impact shows that high-quality reliable information, efficient system, and exceptional customer service have a favorable impact on community engagement. Brands should not only optimize social media content, but also devote time to efficiency and quality of the operational system and services.

Moreover, the relationship between brand community engagement and brand loyalty was found to be highly significant BCE → BL: $\beta = 0.858$, $p < 0.001$), revealing that the pivotal role of community engagement in cultivation brand loyalty. Thus, brands should invest in initiatives that stimulate engagement in online brand communities.

We also examined the parallel mediating impact of information quality, system quality and service quality on social media marketing activities and brand community engagement. It is the aggregate impact of several mediators acting concurrently in explaining how an independent variable (social media marketing activity) influences a dependent variable (brand community involvement). Brand should focus on relevant content, smooth navigation and convenient interaction while marketing their products to fosters engagement in online brand communities.

5.1 Theoretical Implications

The theoretical contributions of this research are twofold. First this study contributes to the brand community engagement by investigating the parallel mediation effects of information quality, system quality and service quality on social media marketing activities and brand community engagement. Information quality and service quality showed significant effects on community engagement. This contributes to a better understanding of how these quality dimensions function as underlying processes. Furthermore, it's worth noting that most past studies on information quality, system quality, and service quality have mostly focused on user satisfaction [79, 80]. The current study, on the other hand, takes a novel approach by studying the impact of these quality factors on engagement in the online brand community, which in turn influences brand loyalty. This shift in emphasis helps to a better understanding of the patterns that influence brand community engagement and loyalty, opening new opportunities for research in this field. Additionally, incorporating social media marketing activities, information quality, service quality and system quality as stimulus in S-O-R framework offers a holistic view of stimuli influencing customer experience.

5.2 Practical Implications

The study emphasizes the importance for marketers to recognize the tactical role of social media marketing activities in enhancing brand community engagement and brand loyalty. Instead of considering social media marketing as merely another promotional channel for reaching customers (Cheung et al. 2020), brand should take strategic approach to implement it to enhance not only their promotional endeavors but also the wider facets of information, services, and system quality they offer to their customers. Brands should position their social media brand pages as a platform that offers guidance to resolve customer concerns pertaining to their branded products. Additionally, marketers can also set guidelines and norms that encourage members to contribute correct and comprehensive information. For this, incentive mechanisms such as badges and elevated status can be used. This would substantially increase community engagement. Moreover, incorporating community-driven feedback into creation and implementation of products and services can result in boosting brand loyalty. Brands may consider building a feedback loop in which they proactively handle the preferences and concerns of community members. This iterative approach not only develops a cooperative environment but also demonstrates a commitment to fulfill changing demands of the community, ultimately fostering loyalty.

6 Conclusion and Limitations

This study investigated the complex links between Social Media Marketing Activities (SMMA), Information Quality (InfoQ), System Quality (SysQ), and Service Quality (SQ), Brand-Community Engagement (BCE), Brand Loyalty (BL). Through rigorous examination and analysis, we have uncovered valuable insights into how these factors interplay within the contemporary landscape of online brand communities. The study underscores the relevance of information quality, service quality and system quality for marketers to engage customers. The implications drawn from this study should be viewed considering certain limitations. Primarily, the research was conducted within the boundaries of an online brand community, without specific emphasis on any platform. Consequently, it is recommended that forthcoming research endeavors broaden their scope to encompass a variety of platforms, including e-commerce platforms, facebook, Instagram, product categories or multiple brands. In our study, we focused solely on brand loyalty as the outcome of brand community engagement. Additionally the research has not delved into particular industry, demographic, or regional contexts. Consequently, the findings may lack contextual specificity and may not be directly transferable to diverse settings. Future study should include context-specific analysis to improve knowledge of social media marketing and brand community engagement in various circumstances. However, future studies can consider additional dependent variables such as brand awareness, brand trust, purchase intention. Also, researchers can construct a comprehensive model showing an intricate relationship between social media marketing activities and brand community engagement. Additionally, as the sampling frame predominantly comprises students, the study's limitation lies in its deliberate focus on unmarried individuals with an annual income of less than 5 lakhs. This focus limits the generalizability of findings to a wider population. Therefore, a more diversified sample should be sought for future study.

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Digital Technologies in E-Governance

E-Government and Well-Being: A Cross-Country Study

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Abstract. E-government has long been argued to bring about positive changes economically and socially in a country. With the technological innovations in recent times, the impact of e-government is not limited to broader economic and a few social factors in a piecemeal manner. E-government can mark its widespread impact across all aspects of citizens' lives and support citizens to lead a flourishing life. However, we know relatively little about whether e-government can enhance the overall well-being of a nation. To address this gap, the current study explores at a cross-country level (1) the direct impact of e-government maturity on well-being and (2) the indirect impact of e-government maturity on well-being through corruption and health. A preliminary analysis is conducted using publicly available archival data from 102 countries, which provides an initial indication supporting the line of reasoning presented in the study. The research method and potential implications for the final study are described.

Keywords: E-government · Well-being · Corruption · Health

1 Introduction

For the past two decades, information and communication technology (ICT) has shown enormous potential, which influenced governments across the world to embrace its applications for national development. While ICT was used previously for internal operations within the government, it gradually evolved into e-government for connecting with external stakeholders, such as businesses, citizens, and various other government agencies [4, 17]. E-government essentially refers to using ICTs to provide governmental information and services to these stakeholders [19].

While looking into the e-government literature, three streams are apparent: (a) evolution and development, (b) adoption and implementation, and (c) impact on stakeholders [21]. Initially, most research dealt with the processes and challenges regarding the evolution, adoption, and implementation of e-government. Lately, the focus is more on the third stream of research—understanding the overall impact the e-government could have on its stakeholders, primarily citizens and businesses. Extant research has acknowledged various positive impacts of e-government, such as increased economic productivity, improved public service, increased transparency and accountability, lowered corruption,

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reduced social divide, sound business competitiveness, and greater citizen participation, among others [1–3, 14, 26]. While all these positive impacts are crucial elements for nation-building, they fail to capture whether these benefits are meaningful to people or whether they can support citizens to lead a flourishing life. Tracking these conditions is elementary for public policy, yet we know relatively little about the potential of e-government to help citizens have a thriving and happy life. In other words, the current e-government research falls short of indicating whether e-government maturity[1] in a country can improve the well-being of its citizens. This study addresses this gap and explores the role of e-government in the well-being of nations. Accordingly, the research question (RQ) is:

> ***RQ:*** *What is the role of e-government in influencing the well-being of citizens in a country?*

To address this question, this study draws on the literature on ICT and well-being to theorize that e-government can improve the country's overall well-being by impacting important issues, such as corruption level and healthcare services. In summary, this study explores at a cross-country level (1) the direct impact of e-government maturity on well-being and (2) the indirect impact of e-government maturity on well-being through corruption and health (life expectancy).

The study uses publicly available archival data from 102 countries to conduct preliminary analyses and makes several crucial contributions to the IS literature and practice. First, this is one of the first few studies to identify the significance of e-government in the well-being of a country. It further provides valuable insights into the societal impact of ICTs. In doing so, this study responds to the call for expanding the scope of information systems (IS) research beyond business and management by incorporating societal value or benefits [22]. Second, this study extends the e-government and well-being literature by theorizing how e-government could enhance well-being by reducing corruption and improving the public health system. Finally, it suggests that policymakers and international bodies must emphasize the role of e-government or ICT use by the government to bring positive changes in people's lives.

2 Background and Hypotheses

2.1 Literature on Well-Being

Economists have long argued that people make rational choices and strive to maximize their utility from their decisions. This is based primarily on neoclassical economics, where it is often assumed that people are aware of the utility outcomes of their decisions. However, it is not the utility that impacts people's decisions; instead, decisions often depend on whether or not these decisions would lead to their well-being in the future [7]. Accordingly, past studies have explored several factors associated with people's subjective well-being. Most factors concern people's demographic profiles, such as age,

[1] E-government maturity is defined as the extent to which a country has an online presence for delivering public information and services [19, 20].

sex, marital status, race, income status, and unemployment [8]. For instance, some studies observed a non-linear relationship between age and well-being; people between 32 and 50 had the lowest well-being level [8]. In other research, wealthier people have a higher level of well-being than poorer ones in some countries [8]. Apart from demographics, some studies observed leisure time outside of obligated work time to promote subjective well-being [24]. There are similar other social, economic, and environmental factors that can predict well-being [10]. In summary, the literature argues that the utility outcome cannot entirely explain people's decision-making. Their subjective well-being could also drive the decisions [8, 10]. While most studies have focused on demographic and socio-economic factors, the role of technological interventions in promoting well-being is hardly explored [18], thus leaving a void in the literature. This research addresses this very gap by understanding how technological advancements in a nation could foster the well-being of its people.

2.2 E-government and Well-Being

ICT is one of the central pillars of a country's development in this digital transformation era. Prior research has shown how ICTs could benefit nations, mainly regarding productivity or GDP [5, 6]. We must understand that ICTs can not only change a nation's productivity but also enhance its citizens' well-being beyond GDP [10]. Nevertheless, the research uncovering the role of ICTs in impacting well-being is in the nascent stage. Only a few studies have examined the linkage between ICT use and well-being. For example, Ganju et al. [10] conducted a panel data analysis and showed that ICT use could be positively related to subjective well-being in a country. In another study, Khan et al. [18] found that the well-being of a country varied with the level of ICT diffusion among individuals and businesses in that country and concluded that a greater diffusion of ICTs will increase the well-being of a nation. While these studies focused on the role of ICTs in explaining well-being, they were limited to theorizing ICT use by individuals or private sector systems. This study argues that the well-being of a nation may not just be driven by ICT use by individuals and businesses; it could also be driven by ICT usage by the government (i.e., e-government).

As stated previously, e-government refers to using ICTs to facilitate the access to and delivery of various government services [15]. It has long been argued to result in positive economic benefits, public administration (transparency), service delivery, and society [1–3, 25, 27]. While these benefits are noteworthy, we know relatively little about whether e-government could improve the overall well-being of a country. Besides contributing to the economic and a few governance factors, as most prior studies argued, this study posits that e-government can mark its widespread impact across all aspects of citizens' lives and enhance the well-being of a nation.

The extant studies conceptualize a country's well-being regarding social capital, social equality, good health, and commerce [10]. The current study extends this conceptualization to argue that people's lives can also thrive when they experience good governance and less corrupt practices in their country [23, 31]. The linkage between e-government and corruption is well-discussed in the literature [19]. Many studies posit that e-government can be an effective tool to mitigate corruption [1, 9, 21]. For instance, Pathak et al. [25] observed that e-government projects could mitigate corruption in the

government by promoting good governance in Fiji. Similarly, Bhuiyan [2] reported that e-government initiatives improved public service delivery, reduced poverty, and controlled corruption in Bangladesh. Less corruption tends to construct a better economic condition and more happiness [28]. In Bhutan, citizens were found to be happier when there was a sound anti-corruption policy in their country [31]. Similarly, citizens in China experienced a higher level of well-being when their perceived official corruption was low [23]. Thus, this study argues that citizens will experience less corrupt practices to afford governmental services in a country characterized by high e-government maturity, which, in turn, will affect their level of well-being.

Secondly, e-government can improve the delivery of healthcare services and management of the public health system. Many countries have started promoting e-health or digital health to improve healthcare delivery considerably. For instance, during the COVID-19 pandemic, e-government portals were used to increase awareness and health literacy by guiding individuals, including disadvantaged people. E-government initiatives also help governments provide health care services in remote and inaccessible areas through telemedicine [11]. Citizens can register and book appointments online, make online payments, and acquire diagnostic reports online [11]. All this eventually translates into citizens' well-being in a country. Based on the above arguments, this study hypothesizes:

H1: *E-government maturity in a country will be positively related to its citizens' well-being.*

H2: *E-government maturity in a country will be positively related to its citizens' well-being by reducing corruption levels.*

H3: *E-government maturity in a country will be positively related to its citizens' well-being by improving healthcare.*

The research model depicting the hypotheses is shown in Fig. 1.

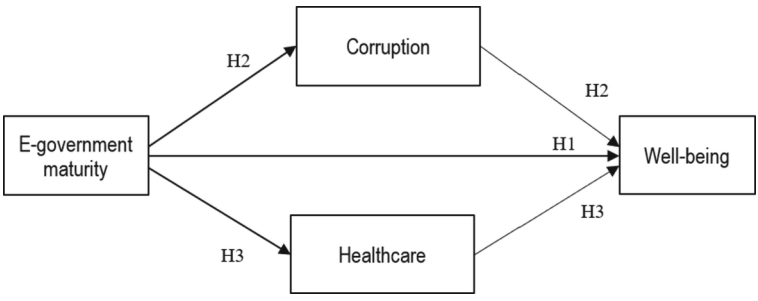

Fig. 1. Research Model

3 Research Design

This study has gathered publicly available archival data from 102 countries to test the hypotheses. The dependent variable, well-being, is operationalized using a well-acknowledged metric of subjective well-being by the Gallup World Poll (GWP) [13]. The GWP obtained the score of well-being on a scale of 0–10, with "0" being the worst possible life and "10" being the best possible life (high well-being). The independent variable, e-government maturity, is operationalized using the United Nations [30] measure of the Online Service Index. The values of this index range between 0 and 1 based on the quality of the government's delivery of online services in a country, where the higher values represent the higher level of e-government maturity.

The intervening variables in this research model are corruption and healthcare. Corruption is measured using the perception of corruption indicator taken from the World Happiness Report [13]. The values of this indicator range between 0 and 1, where "0" and "1" indicate the absence and presence of perceived corruption, respectively. The variable healthcare is operationalized using the life expectancy at age 60 (years) measure taken from the World Health Organization [32]. The study also plans to use two control variables as part of the final analyses, namely: (1) regional difference as conceptualized by the World Bank and (2) primary education (gross enrollment ratio) measured by UNESCO [29].

4 Preliminary Analyses

Table 1 presents the descriptive statistics and correlations for all variables. It was observed that e-government maturity was positively and significantly correlated with well-being. It indicates that the level of well-being in a country can increase with the increase in the degree of e-government maturity, which is in line with what was hypothesized (H1). Further, e-government maturity was found to be negatively correlated with corruption, and corruption was negatively correlated with well-being. It indicates that when e-government maturity increases, corruption can decrease. And, with the decrease in corruption, well-being can increase, supporting the line of arguments in hypothesis H2. Table 1 also shows positive correlations between e-government maturity and well-being and between life expectancy and well-being, supporting the views and reasonings described in hypothesis H3. In sum, the preliminary analyses from correlation statistics endorse, to some extent, the line of reasoning described in the hypotheses, which will be further validated empirically in the final analyses.

As part of the final analyses, the possibility of multicollinearity will be assessed before embarking on hypothesis testing. The hypothesized relationships will be estimated through Structural Equation Modeling (PLS-SEM) followed by Hayes' [12] regression-based mediation analysis in PROCESS.

Table 1. Descriptive statistics and correlations

	M	SD	EDU	REG	EGV	COR	LFE
EDU	102.956	11.894	–				
REG	3.765	2.252	.143	–			
EGV	0.649	0.229	−.125	−.750**	–		
COR	0.713	0.180	−.068	.237*	−.381**	–	
LFE	20.792	3.153	−.048	−.680**	.795**	−.444**	–
SWB	5.593	1.266	−.143	−.714**	.760**	−.467**	.760**

Note. N = 102; M: Mean; SD: Standard deviation; EDU: Primary education; REG: Regional difference; EGV: E-government maturity; COR: Corruption; LFE: Life expectancy; WEB: Well-being; *p < 0.05 **p < 0.001 (2-tailed)

5 Discussion, Implications, and Future Research

5.1 Implications

This study underscores the significance of e-government development in a country for its well-being. It explains how a higher level of e-government maturity could positively impact well-being by changing a country's corruption level and healthcare (life expectancy). In doing so, this study contributes to the IS literature and practice in several ways. While the prior research highlighted that individuals' and businesses' use of ICT in a country could influence well-being, little was known about the impact of the government's ICT use or e-government. With the maturity of e-government portals, citizens can access more governmental information and services at their doorstep from anywhere. They can even raise their voices against fraud and grievances through public grievance portals. All this contributes to their well-being. This research thus makes significant contributions to the literature on ICT and well-being by understanding e-government maturity as a potential determinant of well-being. Secondly, this study posits how e-government could contribute to well-being by reducing the chances of corruption and improving healthcare. This study explains that e-government increases the transparency and accountability of government deeds and helps people access public information and services without bribes, enhancing their well-being. Similarly, e-government could improve the public health system through various digital health services and the overall well-being of people in a country. Lastly, this study is among the few that understand the societal impact of ICT and discusses how e-government could exert societal impacts in the form of well-being.

From a practical standpoint, this study suggests that policymakers emphasize improving e-government initiatives and services for the greater well-being of their countries. They may pay attention to the accessibility of e-government websites and various e-services to most people. Further, policymakers must validate that e-government initiatives are designed to reduce petty corruption and facilitate individuals in obtaining healthcare services to uplift the overall level of citizens' well-being.

5.2 Limitations and Future Research Directions

This study is one of the first few studies to focus on the role of e-government in enhancing the well-being of a country, and it also understands the mechanisms through which e-government can impact well-being. It explains that e-government maturity can impact citizens' well-being by reducing corruption and improving healthcare. While these factors are crucial, other mediating factors (e.g., social equality) could explain the relationship between e-government maturity and well-being. Future research can focus on identifying such factors for richer insights. Secondly, e-government offers citizens opportunities to co-create public services [16] through events such as hackathons. Future studies can focus on such co-creation activities and explore their impact on citizen empowerment and well-being.

6 Conclusion

Despite the widespread use of ICTs by the government, limited research is carried out to understand the role of e-government in the well-being of a country. As an initial step to address this void, this study underscores e-government as a policy-level tool to enhance well-being. It emphasizes that e-government maturity can significantly contribute to the well-being of a country by decreasing corruption levels and improving healthcare. In summary, the author firmly believes that in a world where people and countries are racing fast with technological developments, this study brings refreshing insights into whether e-government can contribute to the well-being of a country.

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Information Security Awareness Safety Governance Model for Senior Citizens in Indian Banking Sector for Mobile and Internet Banking

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Abstract. Digital Baking is emerging with the need for faster and easier access to banking services. As newer technology is emerging, so is the way banking services are changing. One of the concerns that we wanted to address in this paper is about the senior citizens who perform the banking transactions and avail banking services mostly in an offline mode making them vulnerable. The paper wants to highlight how, in a secure manner, some of them are trying to get accustomed to the newer banking services using the mobile and internet banking channels. Hackers are keeping a close eye to tap into the senior citizen customer segment because many of them are naïve to the current technology. We see many instances where senior citizens are successfully hacked and their hard-earned money is lost. This is a social concern that the paper is trying to highlight and shall address this issue by building an Information Security Governance Model, which could be encouraged among the senior citizen population in India. There are many governance models that we might have come across, but our focus is to simplify the communication. We want to build a mechanism by which the senior citizens could understand and become comfortable in following the process by making their transactions more secure while availing the digital banking services.

Keywords: Digital Banking · Governance Model · cyber-Victim

1 Introduction

1.1 Overview of Senior Citizen Population in India as of 2021

As per Elderly India 2021 [1] the projection on the number of elderly male and female population is 66.8 million and 71.1 million respectively. In the next decade, we expect that the number of elderly populations is going to increase by around 30% to 40% on an average. Further, we see that the population, irrespective of gender, is growing more in

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rural (57.4 million) than in urban (19.2 million) areas of the country. We have observed that 10.1% of the population in 2021 is above the age of 60 which is a significant number. From the study, we see that there is a year-on-year average of 64.97 million senior citizens since 1961, out of which we have the 33.58 male senior citizens and 34.38 female senior citizens. Please refer the Table 1 below.

Table 1. Elderly population (aged 60 years and above) in India (in millions): Source Elderly India 2021 [4]

Year	Person	Male	Female
1961	24.7	12.4	12.4
1971	32.7	15.8	16.9
1981	43.2	21.1	22.0
1991	56.7	27.3	29.4
2001	76.6	38.9	37.8
2011	103.8	52.8	51.1
2021	137.9	66.8	71.1

1.2 Traditional Banking to Digital Banking

In India, when we look at the banking sector a decade ago, banks used to work in a traditional model. The model demanded the customers to frequently visit branches to perform transactions and avail various services over the counter. Today is the era wherein, with the help of smartphones all the services are available on the fingertips. This is a great transition and transformation that the banking industry has witnessed which now provides the customer with flexibility and ease to use. Uma Raghavendra Gurram [2] in her paper did a study on digital banking studying the various features that got implemented over the years which made the customer and bank work seamlessly. This change had brought greater flexibility such as operating your account round-the-clock from your digital gadgets such as mobiles or tablets etc., and not depending on the branch's working hours. From the senior citizen's perspective, such digital initiatives are of great help. Further senior citizens with mobility issues could avail the services from home and could reduce frequent visits to the branches enabling them to avail all services without any hassle. It is true that digital banking provides an easier way for customer banking but the concern that we could see is, on the lack of awareness about the safety and secured use of digital banking channels. Many senior citizens are worried about their money being lost by performing online banking transactions. The worry factor creeps in when there are cyber-crimes being reported day in and day out. Hackers are also targeting senior citizens as they are the set of population that could be easily attacked and taken advantage of considering their lack of awareness and knowledge about new age technology.

1.3 Senior Citizen as Cyber-Victim

As per Tripathi, and Kartikeya [3] the youth generation is more tech-savvy and hence they were able to get acquainted with the latest technology quickly but the same is not true with the elderly population. Need of the hour for the senior citizens is good governance. Another perspective that the paper highlights is the cyber incident reporting turnaround time. Currently, senior citizens need to be educated and provided the right direction by sensitizing them about the cyber incidents and their reporting. There is also a need to amend the IT Act which would enable quick and easy ways for channelizing, investing and pushing the hacker away. Though it is true that the law is pressed into action with many e-governance sites for a quick turnaround time, but as the cyber theft cases are on the rise, dealing with large volumes poses a challenge. Another angle to look at this problem is, whether the current set of laws define the correct ownership and responsibility while dealing with the fraudulent cases. It is a collective effort wherein the bank, regulators, cybercrime or information security teams, forensic teams and citizens have to solve the issues together. On the other hand, the citizens also need to be careful about the hackers. They usually lure the citizens, especially the senior citizens into giving away details leading to money being stolen.

With the above objectives, we shall determine the senior citizen's current behavior on the usage of the digital services. Based on the outcome of the survey, the governance model for senior citizens has been framed. The aim for creating the governance model is to simplify the regulatory guidelines and notifications and pass them in an easily comprehendible language to the senior citizens.

2 Objectives

As senior citizen population has significantly increased over the years. The hackers are also targeting them as they are easy preys. As far as the digital banking channels are concerned, the paper focuses on the mobile and internet banking digital services considering that, they are increasingly being used for carrying out transactions. This was the primary reason why we have focused on building governance model specifically around cyber security of the mobile and internet banking channels.

Objectives:

- To understand the inherent awareness of mobile and internet banking channels among the senior citizens.
- To study the comfort with which the senior citizens are able to operate smart phones either independently or with some help.
- To get an insight on how well they are aware of basic cybersecurity hygiene practices.
- To develop a governance model for uplifting the cybersecurity awareness among senior citizens.

3 Study on Cyber Fraud Against Senior Citizens in India

3.1 Case 1: Online Shopping Fraud

As per the report in India Today [5] there was an old lady in her 70s who had visited a shopping website for purchasing toiletries. At the time of payment, she didn't realize the payment was taken double the amount. She clicked on the pay button and completed

her transaction. Thereafter, she realized that the amount deducted from her account was not at the actual cost of the product. The woman tried to take help from the bank for the fraudulent transaction that had happened. But unfortunately, she didn't get immediate support from the bank. The entire fraudulent activity did not stop here and this was the first step of the fraudster. Further, the fraudster called the woman and impersonated as a bank employee. He asked the old lady to download an app on her mobile. By the time this activity was in completed, another lakh of rupees got deducted from her account followed by multiple transactions accounting to 8.3 lacs. Later, a case was logged in the nearest police station. As per the investigation, the fraudster had enabled remote access on the old lady's mobile phone as soon as the app was downloaded. The app gathered all banking related information from her mobile. Had it been a case that the lady was alert or she was made aware of the suspicious download of the app, the entire activity could have been avoided and also the loss of money.

3.2 Case 2: Social Engineering and *Vishing*

Another interesting case was reported in Times of India where a simple use of pretext was used by the hacker to get the details of PAN and Aadhar number [6]. The targeted user was a senior citizen. The pretext was crafted with an intention to promise and build trust to get the insurance amount worth Rs. 7.7 crore by surrendering their life insurance policy. The fraudster recommended opening a bank account with the details of Aadhar and PAN. Post this, a fake certificate having the look-a-like stamp and seal of the regulatory body was shared with the victim. There were around 14 such cases registered against the same gang and three victims were elderly people among the various victims that the gang had duped. This is a classic example of how vishing and social engineering issues could victimize citizens especially the elderly population.

3.3 Case 3: Fraud via Social Media (Telegram) Usage and Targeting Human Emotions

In many cases, the fraudster would try to create urgency or a situation where he makes you feel greedy by offering you great deals. One such case happened in Kolkata [7] where a fraudster gained trust of a senior citizen to convince him to invest his money in crypto-currency and promised to get him a handsome return. Ultimately, the victim lost around 69 lacs. The communication that was shared by the hacker was over *WhatsApp* and later the victim was made to join a Telegram group. Because he was convinced that this was a genuine group, the victim joined and further invested his money into a platform named *Binance.* The victim followed the process as defined by the hacker over the group, where they parked, and invested the money. After some days, there were multiple transactions performed on the victim's bank account, and the entire money was siphoned off.

3.4 Senior Citizen Governance Model for a Bank

A Senior Citizen Banking Governance Model will help to cater to the banks' senior citizen customers by providing an approach to improve their services and also build security

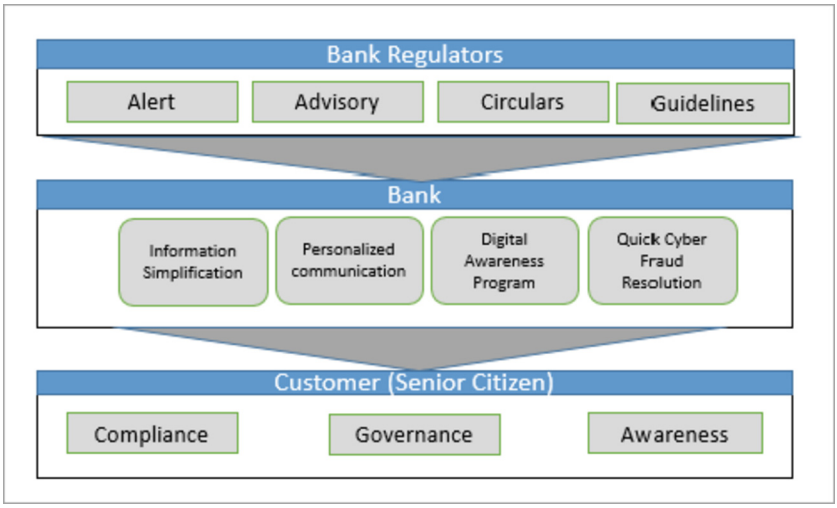

Fig. 1. Banking Governance Model for Senior Citizens

around those. The model is designed to make sure that we are in-line to the regulatory requirements, and, at the same time, are focused on providing flawless governance to the customers who may not be familiar with the technology and cyber security aspects. Currently we see the flow of information from the regulators to the bank and to the end customer is taking place the challenge is in decoding by the end user. As we see that the importance of the model is to make customer understand and act on the clauses easily especially from the cyber security point of view. It is therefore an important aspect where this model will help. Further bank's innovative and creative thinking on how to portray these information also plays an important role. The end objective of the model is easy, clear and understandable flow of information with the customer (Fig. 1).

3.4.1 Bank Regulators

Alerts, advisories, circulars, and guidelines:

Banking Regulators such as *RBI, SEBI,* etc. are continuously updating and upgrading the advisories, circulars, alerts, and guidelines on cyber security & information security aspects. The mandates and the suggestions from the regulators help the bank to maintain a good security posture. As the technology advances, banks have to upgrade their IT infrastructure and be at par with the compliance dictated by the regulatory body. This will help to make their infrastructure resilient to cyber-attacks. At frequent intervals, regulators float customer-specific awareness information, which is required to be cascaded to the customer, both by the bank as well as regulators. The governance model will help the bank to simplify the information that they receive from the regulators and pass it on to the customer (as applicable) in a layman's language understandable to the end consumers.

3.4.2 Bank

Information Simplification:

The model helps the bank to convert the information received from the regulators to be passed on to it's customers in a more simplified manner. Banks can convert it into a naive language or *dialect* so that senior citizens can comprehend. The specific set of directions by regulators are especially from the cyber & information security customer awareness perspective. As an example, if the regulator recommends the customer not to use any public network while performing banking transactions to avoid any data leakage or hacking attempts, the bank also should inform the customer. Such alerts may be technical in nature for the senior citizens to understand but could be simplified with visual representation by the bank.

Personalized Communication:

Personalized communication always will have a great impact when it comes to information sharing. For a senior citizen, personal attention in the branch or providing walk in services at home would make them comfortable and create a trustworthy environment. Such facilities would become a boon for many senior citizens who are alone or have no family support. It may lead to a long-term relationship with the bank. Communications via email or flyers, which guide cyber-safety when dealing with the internet and mobile banking applications, may help the customer to get self-educated about various fraud possibilities. The study conducted by Archana, S. & Paulin et al. [11] highlights the worry about difficulty for senior citizens to absorb the latest technology and services which are available today. As recommended, personal communication could help better.

Digital Awareness Program:

A Digital awareness program, if initiated by the bank at frequent intervals, can have a great impact on how senior citizens can perform transactions safely using the digital banking channels. A helpline or video-based information in the local language could be displayed for the customer walking into the branch. The bank can also display guidelines on the internet or mobile banking site/application. Such programs, when conducted at regular intervals, would help in itching the guidelines in the senior citizen's DNA to avoid any cyber-frauds.

3.4.3 Customer (Senior Citizen)

Compliance:

One of the outcomes of the governance model is to make sure that the bank is compliant with the regulatory requirements. The direction shared by the regulators must be acted upon by the banks as per the applicability. By aligning to the regulatory guidelines, the bank will be able to achieve a win-win situation by satisfying the customer as well as ensuring the security of the customers' transactions.

Governance:

Governance can serve as a pathway as to how the solutions and the various programs could be run so that compliance is achieved and the awareness among senior citizens on cyber security aspects is percolated. Maintaining the alignment with the regulations and providing creative services could be initiated by the bank to ease the customer

journey. Many customizations in the process and policies over and above the regulatory requirements can be brought in. This, will ensure financial inclusion with cyber safety measures being included as part of the bank's customized account opening kits.

Awareness:

Spreading awareness among senior citizens is challenging, but the way we approach them is the key. The banks need to help them to understand cyber security measures making them more confident about using the digital channels for availing the banking services. Awareness sessions can be planned through various means in iterations throughout the year. With the help of strong governance and at the same time adhering to the regulations, the bank could achieve the goal of making senior citizens engage in such programs. One of the suggestions is to have an integrated approach where we bring both the teens and the senior citizens to a single platform. This will help the teens passing on the knowledge they possess to the senior citizens. If each bank volunteers in such initiatives, then confidence and trust in using the online services with necessary precautionary measures could be elevated.

3.5 *"1930"* – A Step Ahead to Report Cyber Frauds Online

The government has come up with many initiatives to help the citizens (especially senior citizens) who are the victims of cyber frauds. The National Cyber Crime Reporting [8] site, with an emergency number of *1930 is one the classic examples.* As per the instructions provided by the Maharashtra Cyber police, the victim of cyber fraud needs to call the helpline number immediately once it is suspected that there has been a fraudulent transaction. If the intimation of the fraud is reported within the first hour of the said transaction, which is termed as Golden Hour [9], the likelihood of money being recovered is the most. As per the police department [9], during the golden hour, money transaction is performed from a central account or the source from where the money will be transacted. Post this time, money will be destined to multiple locations, which is termed as money getting diluted [9] and hence it would be then difficult to trace.

4 Survey Analysis on the Awareness of the Digital Banking System Among Senior Citizen

4.1 Survey Approach

We have taken the approach of designing a simple information gathering mechanism using Google Forms. The survey data was collected within two weeks. One of the challenges that we faced while floating the survey and getting it filled by senior citizens was lack of knowledge on use of technology. Therefore, we have come up with the thought process to float the form to the family members who can help in updating the data on the senior citizen's behalf. In parallel, there was a physical survey conducted which was later manually punched into the Google Forms to make it a central responsibility for further analysis. The Stratified random sampling method was used as we see that there are chances that, in the whole population, every member who is a senior citizen is likely to get a chance to take the survey. The total sample size that we received is around 86

people. There was a data cleansing, followed by the data coding performed. Post these steps, the accepted sampling size was 85 people. We considered the sampling error as 0.5%. The biasing issue amongst the male and the female employee is taken care off by removing the outliers from the data collected from 86 people and after considering those data points that represent no errors. These aspects were considered to cleanse the data collected.

4.2 Methodology and Hypothesis

The population surveyed was from Mumbai, Navi-Mumbai, and Thane areas. For testing the Hypotheses, the chi-square test is considered, as we wanted to understand if there is any significant correlation among the variables defined in the senior citizen population. Most of the responses in the survey were binary. And the questions where we had multiple responses were converted into the numeric value for conducting the test.

4.2.1 Hypothesis Testing and Analysis

Hypothesis 1:

Null H0: Gender has no significant difference regarding the usage of mobile and Internet banking

Alternate H1: Gender has significant differences regarding the usage of mobile and Internet banking

For Female Respondents: Nine respondents said that they always do mobile and internet banking while 20 never transact online and five would sometimes make use of internet and banking services.

For Male Respondents: Thirteen respondents say that they always do mobile and internet banking while 12 never transact online and twenty-five would sometimes make use of internet and banking services.

Table 2. Chi-Square Test result for Hypothesis 1

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.877[a]	3	.002
Likelihood Ratio	16.033	3	.001
N of Valid Cases	85		

As per the Chi-Square Test, in Table 2 the p-value is 0.002, which is less than 0.05, and hence we reject the null hypothesis and accept the alternate hypothesis. *There is a significant difference in Gender and mobile-internet banking services.*

Hypothesis 2:

Null H0: Usage of Mobile and Internet banking has no significant difference in the awareness of the cybersecurity concepts among senior citizens.

Table 3. Chi-Square Test result for Hypothesis 2

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.894[a]	6	.000
Likelihood Ratio	49.478	6	.000
N of Valid Cases	85		

Alternate H1: Usage of Mobile and Internet banking has a significant difference in the awareness of the cybersecurity concept among senior citizens.

One of the respondents who use Internet-Mobile Banking is not aware of cybersecurity. Eleven of them have heard about cybersecurity and ten know about cybersecurity. Twenty-five have never used the Internet-mobile banking services, seven have heard of Cybersecurity and only one respondent is aware of cybersecurity. Among the category where the respondents intermittently use Internet-mobile banking with no cyber security knowledge were three, fourteen of them are aware of cybersecurity and thirteen know about it. As per the above Table 3. Chi-Squared test, the p-value is .000 and hence we accept the alternate hypothesis, which depicts that *there is a significant relation between the use of mobile and Internet banking with that of awareness on the cybersecurity concept.*

Hypothesis 3:

Null H0: Usage of Mobile and Internet banking has no significant difference in performing the banking transaction independently

Alternate H1: Usage of Mobile and Internet banking has significant differences in performing the banking transaction independently

The respondents who sometimes avail the service of Internet-Mobile banking and take help from the family for performing transactions are Eight, Family and Friends One, Self and Family Three, and Nineteen of them perform it independently. The second set of respondents who never use the Internet-Mobile, banking services are dependent on their family and others to perform a transaction on their behalf are twenty-nine, and who do it by themselves with no dependency are Three. Among the set of respondents who always avail the service of internet-mobile banking and take help of the family is One, and twenty perform independently. As per Table 4 the P value is less than 0.05, we are rejecting the null hypothesis and accepting the alternate hypothesis.

Table 4. Chi-Square Test result for Hypothesis 3

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	48.826[a]	9	.000
Likelihood Ratio	56.709	9	.000
N of Valid Cases	85		

5 Challenges, Assumptions, Discussion and Findings

- It was observed that, many senior citizens had never taken an online survey prior to this one. This came out as a major challenge while conducting the survey. Considering this fact: The respondents may take help from their family members and friends for filling the survey on their behalf.
- The family members and friends of the respondents may have to translate the question asked in English into the regional language, understood by the respondents.
- As senior citizens, they may have had challenges in sharing the information.
- We accepted the survey response with a premise that, the family members may have taken the charge of filling out the online survey on behalf of the respondent.
- The current survey was carried out in the metropolitan regions of Mumbai, Navi Mumbai and Thane.

For simplicity sake, the targeted customers are the senior citizens irrespective of their gender. Based on the survey, we could see that the senior-citizens were less aware of the cybersecurity concepts. Moreover, they lack the requisite expertise required to use the smart phones and other gadgets to perform online transactions. This has come out as of the areas of improvement where both bank and customer could work together. The proposed governance model would increase the effectiveness of the cyber security awareness program and also help to enhance the knowledge of senior citizens. It is observed that the regulators are increasingly worried about the cyber-attacks and hence issuing various advisories to prevent those. The proposed model would consider a top-down approach towards cyber security awareness. In addition to above, our model focuses on the other important area where the circulars as shared by regulators time and again may not be easily understood and interpreted by the end users. Going beyond, conducting cyber security workshops and over the counter information sharing would make sure the awareness levels are heightened. The primary focus of the model hence remains to cascade the information from the regulators to the end users especially senior citizens in a simplified manner.

6 Conclusion

We can conclude that, due to incomplete knowledge on cyber security concepts, the senior citizens are getting targeted by malicious users and losing money online. We can consider our study as an effective alert mechanism to help senior citizens get accustomed to the current technology trends. Though, advance knowledge is not the need of the hour, basic knowledge is a must. As described by Whang z [12], there are various methods for social engineering attacks and in some cases, it is tricky to identify them. As mentioned by Breda, Filipe & Barbosa et al. [10] there are various social engineering techniques by which attacks could be carried out, be it *hunting* or *farming*. The same can be applied to carrying out banking frauds as well. As social engineering involves human emotions and manipulating them, technically, such attacks cannot be prevented only using security tools but effective awareness amongst the senior citizens is also a dire need. Senior citizens also most often than not depend on their family and friends to help them performing transactions using their smart phones and laptops. Regulators are

also concerned and hence, they are also forcing the banks to take various initiatives and involve customers to educate them. The proposed governance model will help to address various concerns that we have discussed so far from the senior-citizen's perspective. The model will also make them well-acquainted with the online transaction scenarios. It is known fact that there is no 100% resilience against the cyber security attacks, but our aim is to reduce the probability of individuals (in this case, senior citizens) being trapped or duped by staying alert.

We are also proposing that the cyber security awareness be spread through the bank branches where senior citizens feel homely to walk in. It would be extremely beneficial if the bank's relevant teams could work together to come with up with innovative ideas such as flyers, posters, kits electronically, digitally or physical handouts. Though the model covers major aspects of cascading the information, it is important that the interpretation and the expectation from the customer is coined correctly. We are also planning to extend the model (in near future) to the rural areas. This is considering that this set of population is being targeted by the banks as part of the financial inclusion plans. The learning to take away is "Self-Cyber defense is the greatest defense mechanism against online frauds" where even technology may also not be able to completely secure us.

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Complexity of Last Mile Networks and Ethics of Smart City Interventions: A Case of Solid Waste Management Intervention in Karnataka

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Abstract. Our study delves into potential ethical considerations that emerge within the last-mile service delivery system associated with a solid waste management intervention proposed under smart cities mission in the state of Karnataka, India. We draw upon semi-structured interviews and a comprehensive review of relevant project documents. We adopt a complexity lens to foreground the potential ethical concerns associated with this intervention. Our findings point to the need for smart city interventions to acknowledge the role of existing informal interactions between various actors, and their adaptive capabilities, in fulfilling civic service delivery at the last mile. Such interactions play a crucial role in facilitating a seamless and resilient service delivery process. While some of the interactions are simple and predictable, others are extremely context-specific and difficult to predict.

Keywords: Internet of Things · Smart Cities · Ethics · Public Policy

1 Introduction

Along with ever increasing urban population, the issues and challenges associated with it are also snowballing. Cities are turning to emerging digital technologies such as Internet of Things (IoT), Artificial Intelligence (AI), Blockchain, and so on, to cope up with their challenges, giving rise to concepts like, Smart cities. Smart cities envision data integration from multiple city infrastructure systems – such as transportation, energy, water supply, sanitation, etc., - to improve infrastructure efficiency and civic service delivery by means of data-driven applications [1]. For example, the Smart Cities Mission (SCM) in India aims to utilize the data collected from different infrastructure systems of a city and intelligently employ it for predictive analysis, enabling evidence-based decision-making [2].

The technology of Internet of Things (IoT) plays a crucial role as an enabler for Smart cities. IoT platforms integrate data generated from devices installed in various

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civic infrastructure systems, that are often placed in dynamically changing environments and administered or governed by different parties [3]. Such platforms offer avenues for the city governments to collaborate with the entrepreneurial community to develop data-driven solutions to solve pressing city problems [4].

While the data collected by these platforms hold great potential, it also gives rise to ethical concerns that can potentially lead to societal harm [5]. The ethical concerns appear not only due to the inclusion of personal information, movement patterns, and activity nature of citizens, but also due to the ambiguity surrounding the entities responsible for collecting, managing, and utilizing the data. Additionally, implementers may lack awareness regarding the non-neutrality of data access, use, and its broader impacts [6]. In response, various stakeholders have tried to mitigate the ethical concerns by bringing forward the societal harm, and mobilizing to build responsible data-driven technologies [5].

Given this background, our study aims to provide a grounds-up understanding of the ethical concerns of smart city interventions (SCI), specifically the impact on front-line workers in a Karnataka city, focusing on a smart solid waste management (SWM) system. We explore the following questions- What are some potential ethical concerns facing the frontline workers under the smart SWM system? How are these ethical concerns manifested? In answering these questions, the paper explores the complexity of interactions at the last mile of service delivery and the emergent properties that result from collective behavior.

Our study relies on qualitative research. We employ focus group and individual discussions with frontline SWM workers in the city, also known as Pourakarmikas. Through our interviews, we identify ethical concerns expressed by Pourakarmikas, which we classify into two broad categories: Equity and Accountability. These categories serve as the framework for our discussion in this paper. Using a complex adaptive system (CAS) approach, we investigate the reasons behind ethical concerns in the proposed intervention. Our study emphasizes the need for smart city initiatives to recognize the adaptive nature of interactions at the last mile. Addressing ethical concerns requires the inclusion and empowerment of agents, rather than replacing them with intelligent automation.

2 Complexity and Ethics

Understanding ethics as a social concept and to realize its roots in our social structures is crucial in the context of Smart cities. In this study we adopt a complexity informed view of ethics to interpret our field observations and findings, motivated by the works [6, 7].

SCI's rely on mechanistic notions of city design leveraging data and often ignores the intricate dynamics of cities that are often sustained by social interactions, collaborations, and adaptive capabilities driven by social interactions among human stakeholders. The data upon which SCI are planned often entirely exclude the participation of some of these stakeholders and their role in the development of a city [8, 9]. Understanding complexity of the present cities including the role played by these stakeholders is, therefore, vital to foresee the potential implications of SCI. Indeed, the effectiveness of SCI truly depends on the dynamic social fabric of last mile delivery systems [2].

2.1 Complex Adaptive Systems (CAS)

Simon [10] defines a complex system as a single large system comprising of large number of parts that continuously interact with each other within a specified environment. These systems are often interactive, self-organizing and adaptive in nature which help them sustain change from external interventions and exhibit resilience. Such properties also contribute to an emergent behavior which is often nontrivial and complicated to predict [7, 11]. The diversity and redundancy in agents and their interactions at different levels of the system are the key components in a CAS. It is this characteristic feature that leads to emergent behavior, and imbue the system with capabilities to adapt to changes imposed by external interventions and self-organize internally to stay fit within its environment [7, 12].

In this study we explore a vital complexity feature of civic service delivery systems - the role of agents at the last mile of civic service delivery and the nature of interactions. Our field study on frontline workers of the SWM system brings to light key ethical concerns related to equity, fairness, accountability, and dignity. Two dimensions that prominently emerged were equity and accountability, and below we clarify the meaning we attribute to these two dimensions based on existing literature.

2.2 Equity

The questions of equity in a society deals with problem of equitable distribution of costs and benefits associated with any public intervention [13]. The conversations around equity become prominent when such distributional objectives challenge equity between various social identities or categories [9]. In the context of smart cities, when data-driven interventions promise benefits to everyone in society [14], increased efficiency [15], and improved service delivery [1], similar conversations about equity become important to address. Equity for whom?

Equity is one of the important categories of ethics which debates and foregrounds the questions about the data-driven discrimination, inequal distribution of resources, skewed representations, social identity, and need for developing awareness and mechanisms to combat it. Broadly, it entails the promotion of equality of opportunity/access giving particular attention to the worst-off members of the society [16].

Taylor [14] argues that a just way to address potential inequalities associated with data-driven technological systems (like IoT systems) is to consider both the needs and rights of such actors. Some of the needs include share in the benefits, autonomy to exercise technological choices as per their capabilities, and power to identify and challenge systemic biases. Some of the rights include equitable access to representation, right to information privacy, and right not to be discriminated against [14].

Unfortunately, in a rush to achieve efficiency and profit-maximization goals, data-driven interventions often ignore such needs and rights of different actors. In the context of SCI, one major reason for such neglect is because of an undue preference given to top-down techno-centric approaches over decentralized and bottom-up approaches [17]. This often lead to the risk of excluding or marginalizing certain actors from participating in the city ecosystem [18].

2.3 Accountability

Accountability is often concerned with the process of being called to account to some authority for one's action [19]. It brings in a level of trust and confidence that an entity can ensure to another in the context of fulfilling a specific function or service [20]. In the context of smart cities, a shift towards technocratic mode of governance could pose accountability concerns for different actors. When urban questions are unduly posed as technology problems, they broaden the field of action for technicians, consultants, and large private companies while restricting the participation of others [21]. When the role of the former set of actors increase it often hampers the existing accountability regimes, for instance by creating new digital channels of interaction between citizens and the public agencies who are accountable for civic services.

Such digital channels in SCI are often invisible or opaque to many of the actors within the SWM system. It is, therefore, important for public agencies to attend to the accountability concerns of different actors to mitigate any kind of harm resulting from such interventions. Public authorities should clarify stakeholder liabilities and responsibilities to enhance accountability in SCI and other participating actors [3]. Public authorities may also need to enforce appropriate technical and organizational measures - such as by-design standards, impact assessments, audits, etc.,- to audit the day-to-day operations enabled by such interventions [22]. This helps to improve the overall accountability of the civic service delivery systems for different actors.

3 Methodology

Our study draws on semi-structured interviews and focus group discussions involving various stakeholders associated with the SWM intervention such as: a) Four Smart City officials responsible for overseeing SCI projects in Karnataka, b) Five individuals from academia (professors and researchers) specializing in the fields of SWM interventions, c) Five frontline workers directly involved in SWM system, and d) Five end-users of the SWM system from diverse settings.

Interviews conducted with the first two stakeholder groups offered insights into SCI from an administrative perspective and shed light on the current and proposed state of civic service delivery system. Additionally, we reviewed published smart city project documents, including tenders, proposals, standards, protocols, assessment frameworks, and project reports. Interviews with stakeholders from the academia helped us to understand the designers' and policy makers' point of view about the SWM interventions. Interviews and focus group interactions with frontline workers of the SWM system, specifically door-to-door waste collectors helped us gain insights into their daily work practices, nature of their interactions, and the process through which they operate. Further, we have triangulated insights between the interviews and project documents to build empirical case of a SWM intervention under SCI. To analyze and present ethical concerns associated with these projects, we carefully reviewed and coded the relevant interviews and discussions based on the two ethical principles introduced in the previous section –equity and accountability.

4 An Empirical Case of Solid Waste Management

Before we discuss the empirical case, we provide a brief context about India's Smart Cities Mission (SCM). Initiated in 2015, this mission is overseen by the Ministry of Housing and Urban Affairs (MoHUA) as a centrally sponsored scheme for different states in the country [23]. The primary goal is to support 100 smart cities in developing vital infrastructure and improving urban residents' quality of life [17]. The various candidate cities nation-wide were requested to submit smart city proposals as per SCM program guidelines [23, 24]. Proposals outline the intended 'smart solution applications' for winning and securing the financial support. The SCM encourages cities to engage in a competitive federalism [2]. Selected cities are expected to leverage technology for comprehensive development, attracting people and investments while enhancing quality of life. In the following sections, we discuss the implementation of the SWM system as retrofitting data-driven smart solution which relies on an IoT system to improve the status-quo of SWM in a smart city.

4.1 Proposed SWM Intervention

The management of Municipal Solid Waste (MSW) remains a significant challenge both at global and local level. The challenges of enormous quantities of MSW generated on a daily basis [25] poses an increased risk to frontline workers, who face higher workloads and health hazards such as waste scavenging, particularly in developing countries like India. According to reports, the MSW produced per capita has increased at an exponential rate from 0.26 kg/day to 0.85 kg/day in last two decades in Indian cities [26]. With the rising waste generation, municipalities are facing challenges in waste collection, segregation, and treatment. The Government of Karnataka has taken the initiative to enhance the efficiency of SWM system through smart solutions. Based on interviews with stakeholders, we have created a visual representation of the current SWM network in the city (refer to Fig. 2).

The network flow of SWM system is as follows; The functions of SWM is governed by a designated city authority which outsources the functions of each ward to a private contractor. Each contractor recruits frontline workers for waste collection under two categories; solid waste vehicles and street sweepers. A field officer will be appointed to oversee and report the status of waste collection to the concerned city authority by the state government. The solid waste vehicles traverse door to door in each ward through predefined routes and user groups, on a specified time for collecting wastes. The collected waste at ward level is transferred into large compactors which finally dump the waste at the final disposal sites after recording the weight of the waste.

To reduce information asymmetry between field-level staff, contractors and the city authority, the proposed plan entails implementing an IoT system based on vehicle tracking. The project report of SWM intervention specifies objective of the proposal as to increase household level coverage, and efficiency of collection by minimizing MSW and increase its reuse. Execution of this proposed intervention is outsourced to a third-party agency (technology vendor) and the costs are borne by the city authority (Fig. 1).

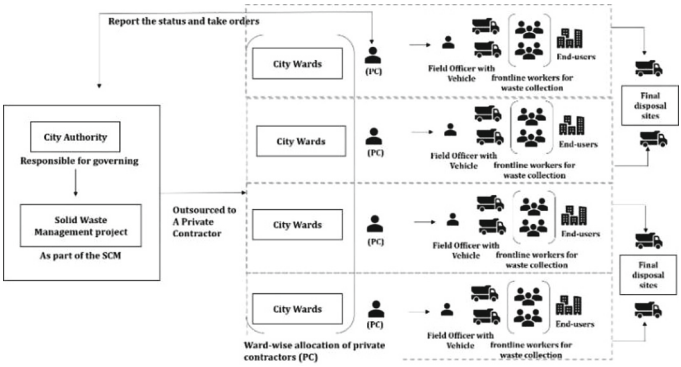

Fig. 1. The network through which SWM system operates in the city.

The proposed SWM intervention aims to provide the city authority with real-time information on garbage collection trends, vehicle tracking, staff attendance and movement, and household complaints for on-demand waste collection. It also enables the prediction of 1) chronic garbage spots, 2) vehicle breakdowns, 3) waste collection based on past trends, 4) efficient scheduling and allocation of pick-up routes, and 5) waste collection based on waste types and associated costs.

To this end, the SWM intervention also envisages its adoption from monitoring of waste collection at the ward level, gradually to household level, and then to citizen level. The process of monitoring includes identifying the property ID associated with every building and use that to track efficient waste collection process till the last-mile. The initiative aims to execute the proposal immediately by using the available digital identities of citizens, frontline workers, and digital devices (such as mobile phones) used by these actors. Frontline workers are expected to scan a Radio Frequency Identification (RFID) or Quick Response code (QR) at each household which then links the household with their property ID to track the amount and nature of waste collected. This data collected at each household can be used to monitor and link the information to generate a household's property tax and SWM tax information. Leveraging this facility, city authorities can now levy dynamic SWM cess for households based on the type and quantity of waste generated. This proposal aims to potentially help city authorities meet one of their sustainability goals which is to nudge households towards zero-waste.

4.2 Network of Frontline Workers

Although the SWM proposals mention the potential involvement of frontline workers, such as waste collectors and street sweepers in the proposal, it largely ignores their daily work process. To gain insights into their operations at the last mile, we draw upon interviews and focus group discussions to illustrate the network through which frontline workers operate in the city (refer to Fig. 3).

Frontline workers are hired by a private contractor through informal social networks. Most of these workers share the same regional background and language. They learn about job openings through their networks and eventually join the contractor for waste

collection. Waste collection is predominantly done by men using vehicles like small autos and large trucks, while street sweeping is mainly performed by women. The waste collection routes and street sweeping areas are predetermined based on the private contractor's assignments. An experienced member or a representative from the contractor supervises and manages the process on a daily basis. They respond to on-demand calls for waste collection, relying on established contacts in the area through phone calls.

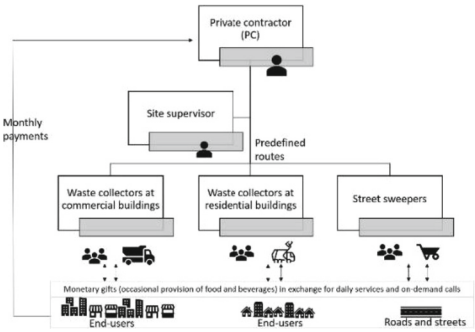

Fig. 2. The network through which frontline workers operate in a predefined local boundary.

The frontline workers operate in two kinds of networks. First, the waste collection at households happens between 5:30 AM and 8:30 AM. The waste collection in residential areas (households and smaller apartments) happens through small green autos. A small green auto will often have two workers, one who stands on the auto (on the collected waste) while the other stands down and hands over the waste (see Pic 1). The waste collectors examine the waste and promptly segregate it on-site, placing different types of waste into separate bags in their immediate vicinity. Certain types of waste that are excessively mixed may be set aside for subsequent segregation at a later stage.

Second, the waste collection from restaurants, hotels, supermarkets, vegetable markets, and large gated communities is facilitated by large waste collection trucks, which play a crucial role in the process (see Pic 2). Initially, all waste is dumped together in these trucks and later sorted for segregation. The larger trucks follow specific predefined routes throughout the day. Additionally, the associated workers often form informal connections with restaurants and small eateries, exchanging services like coffee, tea, breakfast, or lunch in return for collecting waste from these establishments daily. Consequently, they frequently visit during breakfast or lunchtime.

Every month, both these types of networks formed by the frontline workers and the contractors help them receive informal payments from the respective place owners for their services. Typically, apartment associations, restaurants, supermarket owners, and others, provide a lump-sum amount informally to the private contractor. Frontline workers receive informal payments during festivals and for catering to on-demand calls. Over time, they establish communal relationships with different sets of end-users, building networks based on trust and familiarity.

Pic. 1. (on the left) Shows the small autos used for waste collection at residential buildings (Photo credit: Author)

Pic. 2. (On the right) Shows the large trucks used for waste collection at commercial places (Photo credit: Author)

5 Findings and Discussion

"*We need some different clothes, outfits, gloves and shoes to protect us. We stand on waste in barefoot and segregate with bare hands. The only smart solution we want is this, if there is funding for us*!"- a Pourakarmika expresses opinion about the proposed intervention.

'Living laboratories' exclaims Sassen [27] as cities are being constructed using emerging digital technologies like Big Data and AI, transforming them into hubs of urban experiments focused on optimization. Phrases such as 'data is the new oil, 'and 'numbers speak for themselves,' have gained prominence globally. To meet the demands of expanding urban populations, governments increasingly rely on data-driven interventions that interlink large datasets for rapid analysis. In the process they tend to sideline several potential ethical issues. For example, the city official in charge of implementing the SWM proposal acknowledges that '*Privacy and ethical issues are least of my concerns now*,' prioritizing the swift establishment and functioning of the system through available data. However, this approach often leads to the exclusion of certain data points that don't fit the quantifiable framework, resulting in them being considered as 'noise' or assimilated into other data points due to the lack of a specific category to incorporate them [27].

5.1 Complexity of Last-Mile Networks

While quantifying people's lives is not a novel concept, relying solely on technological capabilities can exacerbate exclusion, and social identity issues. An overemphasis on

technocentric solutions like algorithmic fairness and ethics in emerging technologies, can neglect the vital interconnected technical and social structures necessary for timely adaptation and system sustainability[28]. The networks of frontline workers of SWM are a case in point. For instance, one of the Pourakarmikas says,

> *"[during the pandemic], collecting waste posed significant challenges; however, we were able to overcome them through our existing connections, which we established and maintained through regular phone calls".*

The widespread belief of tracking human activities using digital technologies, omits these intangible mechanisms or data points that one may only decipher from the informal interactions between actors within their specific networks. In this regard, studies also recommend the need to acknowledge these diverse data points that often get ignored for those which allow for better quantification [29]. Our field observations indicate that the proposed SWM intervention only presents a partial reality by omitting complex local interactions, and the inherent uncertainty involved in decision-making processes, which are essential aspects of a functioning system.

During our fieldwork, we encountered subjective and contextual data exchanges within informal networks among human agents formed through communal conversations and constant interactions among frontline workers and citizens from diverse backgrounds. Frontline workers often secure their jobs through these networks, as one of them explained, '*I am from Tamil Nadu, I learned about this job from my distant cousin when he visited our home during a festival, and my aunt introduced us.*' These communal conversations strengthen societal bonds, bringing people together even without formal affiliations. Some Pourakarmikas also have very well establish interactions and connections with end-users of the locality. One of them narrates,

> "*For the past eight years, I have been responsible for waste collection in this area, and nearly everyone in the locality has my contact number. They reach out to me whenever there is a need for waste collection. Additionally, I have developed connections with junk shops that provide extra compensation when I supply them with dry waste such as paper and books. With this established network, I am able to operate comfortably and efficiently".*

These data inputs are often rich in contextual information, experience, local problem-solving capabilities that helps sustain the network in unforeseen situations and enhances the resilience of the system. There is enormous potential when these data points are combined with the ones existing (large digital datasets) to embrace different viewpoints and to mitigate any potential ethical concerns, some of which we discuss below.

5.2 Ethical Concerns – Equity and Accountability

Frontline workers expressed a significant ethical concern during the fieldwork, namely the fear of becoming invisible to policy interventions. This concern falls under the category of equity issues, as it stems from socioeconomic factors that hinder equal opportunities. Pourakarmikas often establish informal organizations, such as labor unions, to voice their concerns. As one of them emphasized, *'[we] need to voice out our issues, or*

else we will be forgotten and expected to work like machines without feelings.' The fear of being ignored or rendered invisible is commonly seen as undesirable and is a shared experience among Pourakarmikas, who are often marginalized within society [9]. One waste collector respondent expressed disappointment and described SCM interventions as *'helpless to them'*.

The shift towards technocratic mode and emerging digital technologies in city development raises accountability concerns distinct from existing systems. The technologies providing services often remain opaque and invisible to citizens, both physically and metaphorically [2]. When asked, one Pourakarmika expressed confusion that even within the current system, '*we are often clueless about whose problem it is and who has to solve it*,' referring to waste segregation. The intervention may create accountability risks for frontline workers due to unclear responsibilities and decentralized algorithm-driven decisions that are often beyond their control. End-users may also be uncertain about whom to approach in case of issues. Therefore, it is crucial to clearly define the responsibilities of different stakeholders in such interventions to enhance accountability [3].

5.3 Implications for the Design of Smart City Interventions

Our study argues that it is imperative to acknowledge the complexity of the present city systems, especially the role of agents and their interactions at the last mile, while designing any SCI. In the context of the SWM system, we observed that the network of frontline workers at the last mile are capable of adapting to changing conditions and sustain the process of civic service delivery. There is a danger that when this existing complex adaptive system is forced to tightly couple with relatively rigid technocentric solutions, the shock absorbers (like the frontline workers) may find it difficult to protect the system from failing. Tan and team [11] highlight a similar situation in the context of technology solutionism in a healthcare setting highlighting their importance to the resilience of civic service delivery.

To elaborate this point, we focus on two possible types of interactions in the SWM system: generic and scalable interactions that are simpler and more predictable, and local interactions that require careful observation due to their complexity. Simple and predictable interactions can be addressed using digital quantifiable data, such as tracking waste generation through QR or RFID codes. However, some interactions are complex and difficult to predict. In a focus group discussion with officials and Pourakarmikas, a conversation exemplified this complexity:

> "***Official****: There are a lot of complaints about Pourakarmikas in your area; you are not sweeping the streets regularly. I might have to deduct salary if this continues. [in response]* ***A Pourakarmikas leader****: Sir, they will not work even if you deduct salary. The Pourakarmikas are from the same locality, and they feel ashamed cleaning their area as everyone will recognize them, call them by name, and ask them to clean in front of their houses. If you assign a different area, they will work without hesitation.*"

Typically, job allocation takes into account the proximity of work to maintain a work-life balance. However, in this case, this approach proved ineffective due to specific

socio-economic structures affecting the workers. It is crucial to consider the type of interaction while designing interventions for more holistic solutions.

5.4 Implications for Policy

Our study also corroborates a common theme that public agencies often operate with the assumption that data-driven interventions can offer cost-effective solutions to address city problems. Such an assumption is often speculative. While these interventions are seen as platforms for public agencies to establish data-driven decision-making strategies to improve efficiency and sustainability, it is crucial to recognize the vital role of human agents, their social networks, and their interactions. Even in the context of the proposed SWM intervention, the notion of using data-based platforms and applications to realize dynamic cess for households and guide them towards zero waste requires careful checks and balances for better governing mechanisms. Acknowledging and designing around the parallel negotiation channels rather than disrupting them completely is important to ensure the sustainability of these networks, as they form the foundation of the current service delivery apparatus. Overall, policy makers should take these factors into account to create effective and sustainable smart city strategies.

6 Conclusion

Smart city solutions are frequently enticing due to their data-driven capabilities, offering cost-effective solutions for urban needs. They often serve as platforms for state authorities to develop strategies that align with systemic goals such as efficiency and sustainability. However, once deployed, algorithm driven instructions might disrupt the negotiation channels rising ethical concerns that may become hard to reverse. Our study adopts a complexity lens to foreground ethical concerns, that can potentially manifest from SCI. Our urban systems predominantly operate in an informal manner, where work practices, employment types, and citizens' activities are largely informal. It is crucial to recognize this while SCI are designed. Our findings emphasize the need to acknowledge informal social networks of frontline workers in the last mile of civic service delivery within cities.

We believe, our study can offer valuable insights for various stakeholders. Firstly, policy makers can use our findings to address the ethical concerns associated with SCI. Secondly, technology vendors can benefit from understanding the significance of informal social networks when designing such interventions. Lastly, researchers can build upon our study by exploring similar contexts and SCI. However, it is important to acknowledge the limitations of our study, which focused on a specific smart city intervention in the context of SWM in a particular deployment area. Further research comparing different areas where the intervention is already deployed would provide a more comprehensive understanding of the nature and extent of potential disruptions to the informal social fabric and resulting ethical concerns.

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Examining the Relationship Among Digital Inclusion of Women, National Cybersecurity Maturity, and Wellbeing: A Cross-Country Analysis

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Abstract. This study explores the intricate relationship between the digital inclusion of women, cybersecurity preparedness of nations (aka cybersecurity maturity), and wellbeing. Drawing on the power control theory, we examine how the digital inclusion of women contributes to the cybersecurity maturity of nations. Further, based on the conservation of resources theory, we investigate the relationship between national cybersecurity maturity and wellbeing. Through a comprehensive analysis of cross-country data from 69 nations, this study provides empirical evidence supporting the proposed relationship. Our results demonstrated that digital inclusion of women is positively associated with the cybersecurity maturity of nations. Moreover, we found that the cybersecurity maturity of nations is positively associated with wellbeing. Our findings also indicated that cybersecurity maturity fully mediates the relationship between digital inclusion of women and wellbeing. We tested the robustness of our model by examining the presence of endogeneity using the Gaussian copula approach and the presence of potential specification error using Ramsey's test. Policymakers should prioritize promoting digital inclusion of women by implementing digital literacy programs and creating an inclusive environment by providing internet connectivity, while also investing in cybersecurity through increased funding for research and development, and the implementation of stricter cybersecurity policies.

Keywords: Digital Inclusion · Cybersecurity Maturity · Wellbeing · Mediation analysis · PLS-SEM

1 Introduction

The rapid advancement of information and communication technologies (ICTs) has transformed societies worldwide, creating opportunities for economic growth, social development, and improved quality of life. However, alongside the numerous opportunities presented by the digital age, new challenges and vulnerabilities have emerged, posing significant threats to individuals, organizations, and nations. One of the most critical concerns is the escalating cybersecurity risks, which require urgent attention

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and effective measures to safeguard our digital ecosystems [1]. Consequently, preparedness against cyber-threats has become a crucial element of national security, prompting nations to allocate substantial resources to safeguard their vital systems and citizens from online threats. Cybersecurity breaches encompassing data breaches, identity theft, malware, and phishing assaults can have profound implications for individuals, including monetary setbacks, harm to reputation, and emotional strain [2]. This can lead to severe repercussions on mental health and a sense of security, impacting overall wellbeing.

The International Telecommunication Union (ITU) defines cybersecurity maturity as the level of commitment and preparedness of a nation to fight against cyber-threats through developmental action across five broad pillars: legal, technical, organizational, capacity building, and cooperative [3]. These measures account for regulatory actions to counter illicit activities in cyberspace; adoption and implementation of technological capabilities; development and implementation of new strategies; assigning roles and responsibilities to various national entities for effective coordination; educational and cyber risk awareness campaigns, etc. However, the significance of digital inclusion in achieving the successful implementation of these measures and fostering a resilient cybersecurity ecosystem has become increasingly apparent [4, 5]. Digital inclusion entails ensuring equal, meaningful, and safe access to digital technologies, services, and associated opportunities through the use of the internet [6] and plays a pivotal role in cybersecurity for several reasons. First, it enables broader participation and engagement in cybersecurity initiatives while addressing the diverse challenges and vulnerabilities faced by different communities, ultimately enhancing the overall resilience of the digital infrastructure [7]. Second, it promotes cyber risk awareness and education among individuals who may be more vulnerable to cyber threats due to limited access to resources or lower levels of digital literacy [4, 5, 7].

However, gender disparities persist in digital inclusion, with women facing barriers to accessing and utilizing digital technologies effectively. This disparity not only hampers women's opportunities for empowerment and socio-economic advancement but also creates profound implications for cybersecurity, given that women have been identified as among the most susceptible to cyber threats [8]. Thus, using power control theory [9] as the theoretical basis, which explains the low delinquency behavior among women, this paper tries to investigate the relationship between digital inclusion of women and cybersecurity preparedness (i.e., maturity) of nations. Moreover, as the presence of cybersecurity measures can help alleviate the risk of cyberattacks and associated adverse consequences, which can be a potential cause of negative emotions such as stress, anxiety, fear, etc., we believe that the cybersecurity maturity of a nation is inherently linked to the wellbeing of its populace. Therefore, based on the conservation of resources theory [10], which explains the fear of resource loss leading to negative emotions, this paper investigates the relationship between national cybersecurity maturity and wellbeing. Overall, in this study, we try to answer the following research question:

RQ: What are the relationships among digital inclusion of women, national cybersecurity maturity, and wellbeing in a country?

To answer the above question, we have analyzed archival data from 69 countries on a cross-country basis using the partial least square structural equation modeling (PLS-SEM) technique. Through our work, we intend to make several contributions to the

theory and literature. First, we extend the power control theory to elucidate the relationship between digital inclusion of women and the cybersecurity maturity of nations. By extending the power control theory to this context, we seek to explain how the digital inclusion of women, or lack thereof, affects a nation's cybersecurity maturity. Second, our research theorizes the relationship between the cybersecurity posture of a nation and its wellbeing based on the conservation of resources theory. This approach provides a theoretical foundation for examining how resource investment in the form of cybersecurity preparedness may impact the wellbeing of a nation. Third, to the best of our knowledge, our study is among the first few to empirically verify the relationship between digital inclusion of women, national cybersecurity maturity, and wellbeing. Additionally, we demonstrate how national cybersecurity maturity acts as a mediating factor in the relationship between the digital inclusion of women and wellbeing. The findings could make valuable contributions to the formulation of effective policies and practices that promote digital inclusion of women, fostering cybersecurity, and enhancing wellbeing.

2 Literature Review

Previous research has explored the relationship between gender and the extent of deterrence exercised towards the act of delinquency, revealing that women demonstrate higher levels of self-restraint compared to men [11, 12]. Existing literature also indicates that risk preference is influenced by gender, with males tending to exhibit more risk-taking behaviors than females [13]. Women's limited access to digital resources can exacerbate the existing cyber skills gap and hinder national efforts to enhance cybersecurity [8]. Studies have shown that gender-inclusive digital education programs can improve women's digital confidence and awareness of cybersecurity risks [5]. Such initiatives can also contribute to the development of a cyber-aware society, where individuals are equipped with the necessary skills to protect themselves and their communities from cyber threats [4].

The literature extensively investigates the relationship between cyber-related incidents and wellbeing. Prior research indicates that cyber threat incidents, such as cyberbullying, hacking, and identity theft, can harm mental health and overall wellbeing [2]. Moreover, individuals who have experienced cyber victimization or perceive themselves to be vulnerable tend to exhibit heightened levels of anxiety and stress [14]. Nevertheless, evidence suggests that effective cybersecurity measures can positively influence subjective wellbeing. For instance, individuals who perceive a sense of control over their online security may experience heightened empowerment and self-efficacy, leading to positive implications on wellbeing [15]. Through the establishment of robust cybersecurity measures, individuals experience a greater sense of safety and protection within the digital sphere. Consequently, these measures cultivate a sense of confidence and trust among individuals, contributing to an increased sense of wellbeing [16].

3 Theory and Hypothesis

In this section, we theorize the underlying mechanism linking the relationship between digital inclusion of women, national cybersecurity maturity, and wellbeing. Figure 1 presents the diagrammatic representation of the research framework for the study.

3.1 Relating Digital Inclusion of Women to National Cybersecurity Maturity

Power Control Theory: According to the power control theory, males are more likely to engage in delinquency due to the power dynamics within a patriarchal society [9]. Additionally, delinquent behavior is influenced by individual factors such as self-control and risk-taking propensity [11]. The theory suggests that parental supervision during adolescence plays a role in shaping both self-control and risk-taking attitudes [9]. Greater parental control over daughters affects their self-restraint and risk-taking tendencies. By promoting digital inclusion, women gain access to educational opportunities, training programs, and resources necessary to develop cybersecurity skills. A women-inclusive environment encourages more women to pursue careers in cybersecurity. When women have equal opportunities and representation in cybersecurity roles, it helps to balance the power dynamics within the industry. This reduction in power disparities fosters collaboration, cooperation, and a more inclusive approach to addressing cyber threats. Furthermore, considering that parental supervision, self-control, and risk-taking attitudes are predictors of cybercrime, promoting greater digital inclusion of women can effectively reduce the likelihood of such occurrences and may significantly improve a nation's cybersecurity posture. Thus, based on the above argument, we hypothesize the following:

H1: Digital inclusion of women is positively associated with national cybersecurity maturity.

3.2 Relating National Cybersecurity Maturity to Wellbeing

Conservation of Resources Theory: The conservation of resource theory suggests that individuals are driven to uphold, safeguard, and build resources that are important to them [10]. Resources encompass various entities, including objects, states, conditions, and other elements that are subjectively valued based on individual experiences and circumstances [10]. Derived from this notion, the theory establishes the principle of resource loss. According to this principle, the negative emotional and psychological impact experienced by individuals upon losing resources surpasses the positive emotions associated with acquiring the same resources [17]. As a result, the loss of resources can be a more significant source of stress and exert a more enduring impact on an individual's mental and physical wellbeing, viz-a-viz the benefits of acquiring the same resources. Likewise, resource loss due to cyberattacks, identity theft, or data breaches can evoke feelings of anxiety, vulnerability, and helplessness. Such incidents can engender a sense of losing control over one's digital existence and the ability to safeguard oneself from harm. Consequently, this loss of control can undermine wellbeing by compromising an individual's sense of autonomy, self-efficacy, and resilience. Thus, drawing upon the above arguments, we state the following hypothesis:

H2: National cybersecurity maturity is positively associated with wellbeing of nations.

3.3 Mediated Effects of National Cybersecurity Maturity

After consolidating all the individual components and establishing the connections within our research model, we arrive at a logical deduction of an additional hypothesis.

Our proposition suggests that national cybersecurity maturity acts as an intermediary mechanism or, at least, a partial conduit for the influence of digital inclusion of women on wellbeing. In other words, digital inclusion of women indirectly influences wellbeing by enhancing the cybersecurity maturity of the nation. Thus, we hypothesize that:

H3: The relationship between digital inclusion of women and wellbeing is mediated by national cybersecurity maturity.

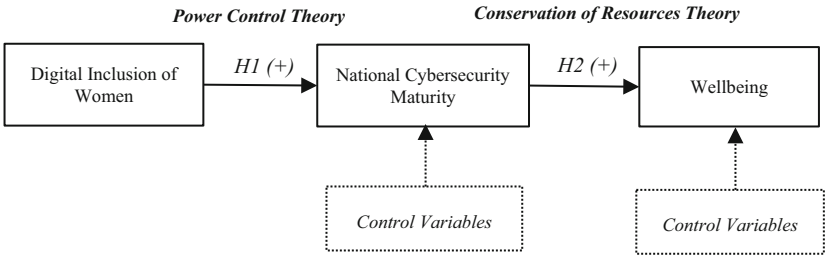

Fig. 1. Research Framework

4 Research Design

4.1 Data

To test our hypothesis, we have used publicly available archival data from various reputed databases. We acknowledge that conducting a comprehensive cross-country study on a large scale is inevitably limited by the substantial time and resources required to collect primary data [18]. Further, the utilization of archival data offers several advantages, including easy replication of results, generalizability of results, and addressing the challenge of common method bias [18]. Our analysis encompasses data from 69 countries (refer to Table 5 in the Appendix for the country list), which can be regarded as a sufficient sample size, exceeding the recommended threshold of 50 to address concerns related to degrees of freedom and efficiency [18]. Additionally, in line with previous research, we have incorporated a one-year lag between the dependent and mediating variables, as well as between the mediating and independent variables [19]. This adjustment allows us to accommodate the time delay in observing the intended effects of any policy interventions. Thus, the data for our dependent variable has been taken for the year 2021, the mediating variable for the year 2020, and the independent variable for the year 2019.

The dependent variable used for our research is wellbeing (WB), measured on the Cantril ladder scale [20]. The Cantril ladder framework, developed by Hardley Cantril, measures life satisfaction by asking respondents to rate their present life position on a ladder with 0 (worst possible life) to 10 (best possible life) steps [21]. Since a person's own experiences are observed in their verbal and non-verbal behavior, the term subjective wellbeing is often referred to as wellbeing [21]. Incorporating subjective wellbeing

as a measure to account for the wellbeing of the citizen allows for a more comprehensive and inclusive understanding of people's overall happiness and life satisfaction. It facilitates informed decision-making and policy interventions to promote the wellbeing of a nation's population. The mediating variable is national cybersecurity maturity (NCM), measured using the Global Cybersecurity Index of the nations [3]. The Global Cybersecurity Index measure the commitment and the level of preparedness of countries worldwide towards achieving a robust cybersecurity infrastructure across five broad pillars, namely, legal, technical, organizational, capacity development, and cooperation [3]. The independent variable taken for the study is the digital inclusion of women (DIW),

Table 1. Summary of variables used in the study

Variables	Notation	Description	Sources
Wellbeing	WB	Measure of citizen's satisfaction with life based on the question "on which step of a ladder numbered from 0 (bottom) to 10 (top) do you feel to stand currently?"	World Happiness Report
National Cybersecurity Maturity	NCM	Measure of the level of commitment and preparedness of the nations against cyber threats	ITU database
Digital Inclusion of Women	DIW	It accounts for the percentage of total female population using internet	ITU database
Government's expenditure on education	GEE	It is the expenditure on education by the government as % of GDP	World Bank
GDP per capita	GDPC	It is the economic output of a country measured as the ratio of the country's GDP to its population	World Bank
Unemployment	UEM	It accounts for the labor force that is without work but seeking employment (measured as the percent of labor force)	World Bank
Mobile-cellular subscriptions	MCS	Subscriptions made to mobile-cellular telephone service that uses cellular technology offering voice communication (measured per 100 inhabitants)	ITU database

measured as the percent of total female population that uses the internet. It accounts for the use of the internet across all digital devices within the country.

Finally, we have employed several control variables in our model. We have controlled for the effect of income and unemployment on our interest variables [22, 23]. For income, we have taken gross domestic product (GDP) per capita as the control, while for unemployment, we have taken unemployment as a percent of total labor force. Further, we have controlled for the government's expenditure on education (as a percent of GDP), as education can contribute significantly towards cybersecurity and the wellbeing of the nation [24]. Finally, we have controlled for the ICT artifact in the form of mobile-cellular subscriptions per 100 inhabitants [25]. Table 1 presents a brief summary of the variables used in the study, along with their respective data sources.

4.2 Descriptive Statistics and Correlations

The descriptive statistics and pairwise correlation between the variables have been shown in Table 2. From the table, digital inclusion of women (DIW) is found to be positively correlated with national cybersecurity maturity (NCM), and both of which are found to be positively correlated with wellbeing (WB). We examined the variance inflation factor (VIF) to determine the possibility of multicollinearity in the model (Hair et al. 1995). The values of VIFs have been found to be in the range between 1.02 to 2.19, which is under the recommended threshold of 5 [26], indicating that multicollinearity is not primarily a concern for our study.

Table 2. Descriptive statistics and pairwise correlation

	Variables	M	SD	1	2	3	4	5	6
1	WB	6.09	0.85	1.00					
2	NCM	0.81	0.22	0.30	1.00				
3	DIW	74.23	17.21	0.71	0.48	1.00			
4	GEE	4.68	1.60	0.37	−0.07	0.20	1.00		
5	GDPC	21543	20981.86	0.76	0.43	0.68	0.23	1.00	
6	UEM	6.29	3.94	−0.27	−0.05	−0.06	−0.01	−0.25	1.00
7	MCS	127.05	22.12	0.18	0.04	0.26	−0.10	0.06	−0.23

Note. N = 69; M: Mean; SD: Standard Deviation; Correlations greater than |0.23| are significant at $p < 0.05$ (2-tailed)

5 Analysis and Results

For the analysis, we have used structural equation modeling (SEM) analysis [27]. SEM is considered useful to test parsimonious models and has several advantages over other techniques, such as its ability to analyze various paths in the model simultaneously, its

capability to accommodate variables that do not follow a normal distribution, estimation of models with very small sample size, and to address the presence of multicollinearity among the variables [27]. We opted to use partial least squares SEM (PLS-SEM) analysis in our study instead of covariance-based SEM (CB-SEM) because of the various advantages it has over CB-SEM [27]. We have done the testing of our model using SmartPLS (Version 4) software [28]. To obtain the confidence intervals and p-values, a bootstrap resampling procedure was employed with 5000 bootstrap samples randomly generated from the original sample [27].

In the model, the constructs used for the analysis have been considered reflective as the measurement items indicate the intended constructs [18]. Table 3 presents the results from the analysis. From the table, digital inclusion of women (DIW) has been found to be positively and significantly related to the national cybersecurity maturity (NCM) ($\beta = 0.424$, $p < 0.05$), supporting our first hypothesis, H1. Further, the results indicated that the mediating variable, i.e., national cybersecurity maturity (NCM), is positively and significantly related to wellbeing (WB) ($\beta = 0.272$, $p < 0.05$), supporting our second hypothesis, H2. We conducted further analysis to understand the mediating effect of national cybersecurity maturity on the relationship between digital inclusion of women and wellbeing using the method suggested by Preacher and Hayes [29]. In accordance with the methodology, we generated bootstrap confidence intervals for analyzing the mediation effect. The test results are shown in Table 4.

The examination of the relationship between the independent and dependent variables in a Preacher and Hayes analysis, as presented in Table 4, involves assessing both the total and direct effects. The difference between these effects represents the indirect influence of the independent variable on the dependent variable through a mediator. Additionally, the examination offers a calculation of the indirect effect exerted by the mediator, while the application of the bias-corrected (BC) bootstrap method generates a 95% confidence interval for the mediator. If this interval does not include zero, it indicates a significant indirect effect of the mediator [18]. First, we examined the total effect of the digital inclusion of women, as the independent variable, on wellbeing, as the dependent variable while treating all other variables as controls. As shown in Table 4, digital inclusion of women (DIW) has a significant total effect on wellbeing (WB) ($\beta = 0.384$, $t = 2.543$, $p < 0.05$). When the mediating variable national cybersecurity maturity (NCM) was introduced, the direct effect of DIW on WB became insignificant ($\beta = 0.109$, $t = 1.558$, $p > 0.10$), suggesting full mediation. Moreover, the difference between the total and direct effect gave the indirect effect as mediated through NCM with the point estimate as 0.239 and the 95 percent BC confidence intervals (CI) of 0.007 and 0.332. These findings indicate a significant deviation from zero, suggesting that the influence of national cybersecurity maturity on the relationship between digital inclusion of women and wellbeing is substantial, thus, supporting hypothesis H3.

5.1 Robustness Test

To validate the robustness of our findings, we checked for endogeneity concerns in our model. In order to achieve this, we adopted the Gaussian copula approach, which is a widely recognized instrument-free approach to check for endogeneity [30]. Using the same dataset mentioned previously, we followed the approach suggested by [30]

to examine the presence of endogeneity. We conducted the Lilliefors corrected Kolmogorov–Smirnov test on variables that could potentially exhibit endogeneity, as it is a prerequisite for employing the Gaussian copula technique [30]. The findings indicated that the independent variable (endogenous) has non-normal distribution, satisfying the criteria. On applying the Gaussian copula on the relationship between digital inclusion of women and national cybersecurity maturity, and between national cybersecurity maturity and wellbeing, the results indicated that none of the copula is significant (p-value > 0.05). We further placed Gaussian copula on the control variables and found similar results, supporting the null hypothesis of no endogeneity present in our model. It should be noted that we examined all other combinations of Gaussian copulas used in the model, and none of them yielded a significant result, addressing the concern of the presence of endogeneity [26]. We also examined our model for potential specification errors to ensure its robustness [26]. Ramsey's RESET (Regression Specification Error Test) is a diagnostic test used to identify potential specification errors in a regression model. The test checks whether a nonlinear function of the predicted values (such as squared or cubed terms) should be added as an additional predictor to the model to capture potential nonlinearity in the relationship between the dependent variable and the independent variables. We tested the presence of quadratic and cubic terms of the independent variables on the dependent variables. The test confirmed the absence of specification errors in the model (p-value > 0.05).

Table 3. Results of the SEM analysis

	NCM		WB	
Independent Variable	Coef	SE	Coef	SE
DIW	0.424**	0.201		
Mediating Variable				
NCM			0.272**	0.146
Control Variables				
GEE	−0.201	0.163	0.424***	0.105
GDPC	0.174	0.171		
UEM	−0.012	0.161	−0.218*	0.11
MCS	−0.096	0.121	0.124	0.11
R-square	0.300		0.310	
R-square adjusted	0.243		0.266	

Note. N = 69; SE: Standard error; Standardized path coefficients were reported; WB: Wellbeing; NCM: National Cybersecurity Maturity; DIW: Digital Inclusion of Women; GEE: Government's expenditure on education; GDPC: GDP per capita; UEM: Unemployment; MCS: Mobile-cellular subscriptions; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 4. Mediation analysis results

Total effect: IV on DV		Direct effect: IV on DV		Indirect effect			
Coef	t-value	Coef	t-value		Point estimate	BC 95% CI	
						Lower	Upper
0.384**	2.543	0.109	1.558	NCM	0.239	0.007	0.332

Note. N = 69; 5000 bootstrap samples [29]; R-square = 0.696; IV: Independent variable (Digital inclusion of women); DV: Dependent variable (Wellbeing); BC: Bias-corrected bootstrap; CI: Confidence Intervals; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

6 Discussion and Implications

The present study explored (1) the relationship between digital inclusion of women and the cybersecurity maturity of nations; and (2) the relationship between the cybersecurity maturity of nations and wellbeing. Our analysis using cross-country data from 69 countries indicates that digital inclusion of women has a positive association with national cybersecurity maturity. This suggests that when women have equitable access to digital technologies (measured by access to the internet) and are actively involved in the digital realm, it positively influences a nation's ability to develop and implement effective cybersecurity strategies. This result aligns with the growing recognition of the importance of diversity and inclusion in cybersecurity, as diverse perspectives and talent pools contribute to more comprehensive and robust defense mechanisms against cyber threats. Moreover, the findings revealed a positive association between national cybersecurity maturity and the wellbeing of a nation. This implies that nations with higher levels of cybersecurity preparedness, resilience, and effectiveness tend to experience better wellbeing. This association can be attributed to several factors. For instance, robust cybersecurity measures contribute to enhanced data protection, reduced cybercrime, and increased public trust in digital systems, thereby fostering a safer and more secure environment. Moreover, effective cybersecurity practices are closely linked to economic stability, as they mitigate the risks associated with cyberattacks and safeguard critical infrastructure, leading to increased economic growth. Additionally, our research highlighted the mediating role of cybersecurity in the relationship between the digital inclusion of women and wellbeing. These results underscore the significance of robust cybersecurity measures in fostering a positive environment for overall wellbeing, while also emphasizing the crucial link between gender-inclusive digital participation and the overall welfare of societies. By mediating this relationship, cybersecurity maturity acts as a catalyst that amplifies the benefits derived from gender-inclusive digital participation, ultimately contributing to improved societal outcomes, i.e., wellbeing.

Thus, based on the findings from the study, we offer several implications for managers and policymakers. First, policymakers should prioritize initiatives that promote digital inclusion of women. This can be done through measures such as increasing access to the internet and digital technologies, providing digital literacy programs, and fostering an inclusive environment that encourages women's participation in the digital space. Second, policymakers should recognize the importance of cybersecurity and allocate sufficient resources to develop robust cybersecurity frameworks. This could mean allocating more funding for research and development in cybersecurity and enacting more stringent cybersecurity policies and regulations. For managers in organizations, it signifies that cybersecurity extends beyond protecting company assets and intellectual property; and involves safeguarding the wellbeing of employees and customers. Consequently, managers should contemplate strengthening cybersecurity training for staff, reinforcing access controls and encryption measures, and formulating comprehensive incident response plans to address potential cyber-attacks. Finally, policymakers and managers should acknowledge the mediating role of cybersecurity maturity in the relationship between digital inclusion of women and national wellbeing. This highlights the importance of a comprehensive approach that considers the interplay between these factors. Efforts to promote digital inclusion should be accompanied by measures to strengthen cybersecurity, as it acts as a bridge between digital inclusion and the overall wellbeing of nations.

6.1 Limitations and Future Research Directions

There are certain limitations of our research, mainly stemming from the use of secondary data. These limitations should be considered and addressed in future research endeavors. First, as we have used secondary data for the study whose data were available publicly through different databases, we urge the replication of our findings using primary data and experimental approaches. Second, our dataset is limited to the data points obtained across 69 countries, whose data were commonly available. Although the sample size is relatively small, we believe our work provides a foundational understanding of the phenomena, which has not been extensively studied. Future research may consider using longitudinal data for conducting the same analysis. Third, we acknowledge that the applicability of our results is limited to the timeframe covered by the dataset utilized in our study. Future research could be conducted to comprehensively assess the generalizability of our findings and account for potential variations that might have occurred over time.

7 Concluding Remarks

In relation to our research question regarding the relationship between digital inclusion, cybersecurity maturity, and wellbeing of a nation, we provide the following conclusions. Drawing from the evidence presented in this paper, we find support for the hypothesis that digital inclusion of women has a positive association with national cybersecurity maturity. We also found support for the hypothesis that national cybersecurity maturity has a positive association with wellbeing. Finally, we found no direct effect of digital inclusion of women on wellbeing. Instead, this relationship is entirely mediated by the cybersecurity maturity of nations.

Appendix

Table 5. List of countries

Albania, Armenia, Austria, Belgium, Bolivia, Bosnia, Brazil, Bulgaria, Cambodia, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czechia, Denmark, Egypt , El Salvador, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Indonesia, Iran, Ireland, Israel, Japan, Kazakhstan, Kenya, Korea, Rep., Latvia, Lithuania, Malaysia, Malta, Mauritius, Mexico, Mongolia, Morocco, Netherlands, Norway, Pakistan, Panama, Paraguay, Peru, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, Ukraine, UAE, UK, Uruguay, Uzbekistan, Vietnam

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The Impact of Digital Technologies on E-Governance: A Comprehensive Analysis

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Abstract. This comprehensive analysis delves into the transformative influence of digital technologies on the landscape of e-Governance. It navigates through foundational concepts, examines five real-world case studies of successful implementations, and elucidates the benefits and challenges in this dynamic arena. The study highlights how digital technologies enhance accessibility, transparency, and efficiency while advocating for measures to address the digital divide and data privacy concerns. This research guides governments toward a future where technology catalyzes responsive, inclusive, and efficient governance.

Keywords: Digital technologies · e-Governance · Comprehensive Analysis · Impact · Citizen Engagement · Government

1 Introduction

Human society has always relied on governance in various forms. Conventional governance focused on face-to-face encounters, bureaucratic processes, and paper records. Digital technologies have created an unparalleled opportunity to influence governance dynamics. Emerging technologies, including mobile apps, Artificial Intelligence (AI), Blockchain, and Internet of Things (IoT), have transformed government operations, services, and citizen engagement [4,11,12,20].

As digital technologies advance, governance landscapes undergo significant changes [23]. Technology and governance have converged to create e-Governance [3]. Integrating digital tools and platforms into the governance framework changes how governments connect with citizens, offer services, and make decisions. e-Governance aims to promote efficient, transparent, inclusive, and responsive systems through digital technologies [16,19]. In e-Governance, electronic platforms and digital communication tools are used to improve government-citizen interactions, expedite administrative processes, and improve governance effectiveness [3]. It includes the Internet services, information for citizens, and data analytics for evidence-based decision-making. Online government services allow citizens to communicate with government entities from home.

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Existing literature focuses on applying various emerging technologies to governance [4,11,12,20]. This research seeks to analyze how integrating these technologies reshapes governance practices and explores this transformation's benefits, challenges, and potential future trajectories. By examining various real-world case studies, strategies, successes, and lessons learned, this study aims to comprehensively understand the various factors contributing to the successful implementation of digital technologies in e-Governance. So, the primary objectives of this research study are as follows:

1. To identify the benefits accrued through the adoption of digital technologies in e-Governance, including improved accessibility, transparency, efficiency, and citizen engagement.
2. To analyze the challenges and concerns of integrating digital technologies in e-Governance, such as the digital divide, data privacy, infrastructure requirements, and legal frameworks.

The motivation behind this research stems from the transformative potential of digital technologies in reshaping the governance landscape. This study seeks to uncover the benefits and challenges inherent in these transformations, offering policymakers, citizens, and stakeholders valuable insights into harnessing technology's power to create more efficient, inclusive, and responsive governance systems. Moreover, as the digital revolution continues to advance, there is a pressing need to anticipate and adapt to emerging trends, ensuring that governance remains relevant and effective in meeting the evolving needs of societies worldwide.

The rest of the paper is organized as follows: Sect. 2 provides a comprehensive review of existing literature related to the impact of digital technologies on e-Governance. Section 3 explores the digital technologies reshaping e-Governance. Section 4 examines the challenges and benefits of these technologies in e-Governance. Section 5 presents five real-world case studies, analyzing successful e-Governance implementations and the strategies that underpin their achievements. Section 6 presents the cross-case analysis of five cases and insights drawn from the cases. Finally, the paper is concluded.

2 Literature Review

The literature on the impact of digital technologies on e-Governance converges around several key themes, providing valuable insights into this dynamic and evolving field. First, a prominent theme is enhancing citizen engagement and participation through digital channels. Studies such as Damodaran and Olphert [8], Matheus et al. [18] and Falco and Klienhans [10] have explored how online platforms and mobile applications facilitate direct interaction between citizens and governments, enabling real-time feedback, collaborative policy development, and participatory decision-making. This theme highlights the potential for digital technologies to bridge the gap between governments and citizens, fostering transparency and accountability [2,5,30].

Second, the literature highlights the critical role of data and analytics in reshaping e-Governance. Various studies emphasize how big data analytics and AI enable governments to harness vast datasets for informed decision-making. These technologies optimize resource allocation and enable predictive modeling for more proactive governance [11,15]. However, a recurring limitation across these studies is the need for robust data privacy measures and ethical considerations, signaling a critical research gap in addressing potential risks and concerns [13].

Another significant theme is the influence of digital technologies on service delivery and administrative efficiency. Nemer [22], Muoz et al. [21] and Chohan and Hu [7] illustrate how digital transformation streamlines bureaucratic processes, reduces administrative overhead, and enhances the accessibility of public services. Yet, a standard limitation lies in the digital divide, where marginalized populations may be excluded from the benefits of e-Governance initiatives. This points to a crucial research gap in understanding how to ensure equitable access and inclusivity in digital governance models. Effective leadership and policy frameworks play a pivotal role in the success of e-Governance initiatives [17,26,29]. Researchers have identified a range of challenges in the implementation of digital technologies in e-Governance. These include technical challenges related to the interoperability and integration of legacy systems [9,14], legal challenges concerning data ownership and liability [28], and organizational challenges arising from resistance to change within government structures [27].

Despite these valuable insights, the existing literature on the impact of digital technologies on e-Governance exhibits certain limitations and research gaps. Many studies focus on successful implementations, potentially neglecting valuable lessons from less successful cases. Additionally, while the benefits of digital transformation are extensively explored, there is a need for more comprehensive investigations into the ethical, legal, and privacy implications associated with the increased collection and utilization of citizen data. Moreover, research that delves into the long-term sustainability and adaptability of e-Governance models in rapidly changing technological landscapes still needs to be explored. Addressing these research gaps is essential for shaping a more holistic and resilient e-Governance framework that maximizes the potential of digital technologies while mitigating associated challenges and risks [32].

3 Digital Technologies Reshaping E-Governance

Digital technologies have profoundly reshaped the landscape of e-Governance, ushering in transformative changes with far-reaching governance implications [23]. This section examines key digital technologies-blockchain, artificial intelligence (AI), and the Internet of Things (IoT)-and their respective impacts on e-Governance, while comparing and contrasting them across critical aspects.

3.1 Blockchain and E-Governance Implications

Blockchain technology, known for its decentralized and tamper-proof ledger system, has the potential to enhance trust, transparency, and security in e-Governance. It can facilitate secure identity management, streamline administrative processes, and enable verifiable transactions, as we will see in Estonia's e-Residency program. However, its implications for governance extend beyond these benefits. Blockchain introduces the concept of decentralized governance models, where intermediaries are minimized or eliminated, raising questions about the role of central authorities in a blockchain-based e-Governance system [11,15].

3.2 AI and E-Governance Implications

Artificial intelligence, with its machine learning algorithms and data analysis capabilities, empowers governments to process vast datasets, automate decision-making, and offer personalized services. South Korea's AI-driven chatbots for public service inquiries exemplify AI's potential to enhance citizen interactions. Nonetheless, AI introduces governance challenges, especially concerning data privacy and ethics. The automated decision-making processes can inadvertently reinforce bias, and ethical considerations surrounding AI's use in governance are critical. Additionally, AI's potential impact on employment within public administration necessitates careful workforce planning [1,20,25].

3.3 IoT and E-Governance Implications

The Internet of Things connects physical devices and infrastructure, offering real-time data for improved governance. In urban governance, IoT sensors can monitor air quality, traffic flow, and waste management, as seen in Singapore's Smart Nation initiative. However, IoT introduces governance challenges related to data security and privacy. The vast amounts of data IoT devices generate require robust cybersecurity measures to prevent breaches [4]. Moreover, ensuring the privacy of citizens' data collected through IoT is an ongoing concern.

3.4 Comparative Analysis

In comparing these technologies, security is a critical aspect. Blockchain is often lauded for its high security standards due to its decentralized and tamper-evident nature. AI, while offering enhanced decision-making, poses data privacy and security risks, mainly if improperly implemented. With its extensive data collection, IoT demands robust cybersecurity measures to mitigate potential vulnerabilities.

Cost implications vary among these technologies. Blockchain, while secure, may have high initial implementation costs. AI investments can be significant, but automation makes long-term cost savings possible. IoT implementations

require substantial upfront infrastructure investments, but potential long-term benefits in efficiency and resource management may outweigh the costs.

The ease of adoption depends on factors such as technological readiness and regulatory frameworks. Blockchain adoption may need more support due to its novelty and potential regulatory challenges. AI requires investments in skills and infrastructure, and IoT may face challenges in establishing standardized protocols for interoperability.

Finally, while each technology offers unique benefits and governance implications, they all underscore the need for robust data governance frameworks, ethical considerations, and proactive cybersecurity measures. Governments must carefully assess their specific needs, challenges, and readiness before implementing these technologies in e-Governance to ensure that the benefits are maximized while mitigating potential risks.

4 Challenges and Benefits of Digital Technologies in E-Governance

4.1 Challenges

- **Digital Divide:** One of the foremost challenges is addressing the digital divide. Not all citizens have equal access to digital technologies, which can lead to exclusion from e-Governance initiatives. Overcoming this challenge through initiatives like subsidized internet access and digital literacy programs can help ensure that e-Governance benefits are accessible to all, promoting inclusivity and reducing disparities in service access.
- **Data Privacy and Security:** The collection and storage of vast amounts of citizen data pose significant privacy and security risks. Ensuring robust data protection measures, stringent encryption protocols, and strict adherence to data privacy laws are essential to building and maintaining citizens' trust. Overcoming these security challenges can increase confidence in e-Governance systems and greater citizen engagement.
- **Lack of Digital Skills and Awareness:** Many citizens, especially in older demographics, may need more digital skills to engage with e-Governance platforms fully. Addressing this challenge requires investing in digital literacy programs and user-friendly interfaces. Overcoming the skills gap can result in greater citizen participation, improved service utilization, and enhanced efficiency in government-citizen interactions.

4.2 Benefits

- **Enhanced Accessibility and Convenience:** Digital technologies enable citizens to access government services and information conveniently from anywhere, reducing the need for physical visits to government offices. Overcoming the digital divide ensures that all citizens, regardless of location or socioeconomic status, can benefit from this increased accessibility.

- **Transparency and Accountability:** Digital technologies promote transparency in government operations by providing real-time access to information, decision-making processes, and public spending data. Ensuring robust data privacy and security measures builds trust in these systems, allowing citizens to engage with confidence and hold governments accountable.
- **Efficiency and Cost Savings:** Automation and digitalization streamline administrative processes, reducing bureaucracy and operational costs. Overcoming the skills gap and investing in digital literacy ensures that government employees can effectively utilize these tools, increasing service delivery and resource management efficiency.

In summary, addressing challenges like the digital divide through inclusivity measures, data privacy and security through stringent protocols, and the lack of digital skills through training programs can realize the benefits of enhanced accessibility, transparency, accountability, efficiency, and cost savings in e-Governance. This holistic approach ensures that digital technologies in e-Governance improve government-citizen interactions and promote social equity and trust in government services.

5 Case Studies

This section presents five case studies from different countries, showcasing successful e-Governance initiatives and analyzing the strategies that led to their accomplishments. These case studies offer tangible examples of how digital technologies can transform governance practices and contribute to improved citizen experiences.

5.1 Estonia's E-Residency

Case Study Overview: Estonia's pioneering e-Residency program grants non-residents secure access to the country's digital services and business environment. With a government-issued digital identity, e-Residents can establish and manage companies, access banking services, and engage with government agencies online (https://e-estonia.com/solutions/e-identity/e-residency/).

Strategies for Success: Estonia's success lies in its early commitment to digital transformation. The government invested in developing a robust digital infrastructure, including secure identity authentication through smart cards. A strong emphasis on digital literacy and education ensured that citizens and non-residents could navigate the digital ecosystem effectively.

Lessons Learned: Early investment in digital infrastructure and education pays dividends in the long run. Building trust and ensuring the security of digital identities are pivotal for encouraging broader participation in e-Governance initiatives.

5.2 India's Aadhaar System

Case Study Overview: India's Aadhaar system (https://uidai.gov.in/) is a massive biometric identification project that assigns unique 12-digit numbers to citizens, enabling access to government services and benefits. It has transformed identity verification and service delivery across the nation [24,31].

Strategies for Success: The success of Aadhaar can be attributed to its scale, integration with various services, and transparent government backing. A robust legal framework was established to address privacy concerns and data protection. Furthermore, the government's active promotion and communication about the benefits of Aadhaar helped build trust among citizens.

Lessons Learned: A robust legal framework and transparent communication are vital for handling privacy concerns. Connecting Aadhaar with multiple services enhances its utility and encourages widespread adoption.

5.3 South Korea's E-Government 2.0 Initiative

Case Study Overview: South Korea's e-Government 2.0 initiative aimed to provide integrated online public services through a single platform. This approach streamlined government-citizen interactions and improved the accessibility of services [6].

Strategies for Success: Collaborative efforts between government agencies were pivotal in creating a unified e-Government platform. The user-centric design and intuitive interface were crucial in driving citizen engagement. South Korea's success is attributed to its strong emphasis on interoperability and information sharing among different departments.

Lessons Learned: Interagency collaboration and a user-centric design are essential for a comprehensive e-Governance platform. Developing standardized protocols and ensuring compatibility between various systems enable seamless service delivery.

5.4 Rwanda's Irembo Platform

Case Study Overview: Rwanda's Irembo platform offers various government services, from business registration to education-related services. The platform aims to simplify citizen interactions with the government (https://irembo.gov.rw/).

Strategies for Success: Rwanda's proactive approach to technology adoption and strong leadership commitment were pivotal. The government focused on developing user-friendly interfaces and providing digital skills training to citizens. This approach facilitated widespread adoption and usability.

Lessons Learned: Providing digital skills training is crucial, particularly in regions with lower digital literacy rates. Incremental implementation and continuous improvement based on user feedback contribute to long-term success.

5.5 Singapore's Smart Nation Initiative

Case Study Overview: Singapore's Smart Nation initiative uses technology to improve citizens' lives. It encompasses various projects, including digital payments, smart transportation, and data-driven urban planning (https://www.smartnation.gov.sg/).

Strategies for Success: Singapore's clear vision and strong government commitment have been driving factors. The government encourages experimentation and innovation, fostering public-private collaborations to leverage expertise and resources effectively.

Lessons Learned: Visionary leadership, commitment to innovation, and public-private collaboration are essential for a holistic digital transformation. Adaptability to evolving technology trends ensures the sustainability of initiatives.

6 Cross-Case Analysis

This section presents Cross-case Analysis of these five e-Governance case studies with respect to the parameters including digital identity initiatives, data security and privacy, citizen-centric design and user engagement and policy frameworks. It also presents the key insights drawn from case studies.

6.1 Digital Identity Initiatives

Both Estonia's e-Residency and India's Aadhaar System highlight the significance of robust digital identity initiatives. Estonia's e-Residency provides a secure digital identity to non-residents, enabling access to government services, and businesses globally. India's Aadhaar, one of the largest biometric identity projects globally, offers a unique identity number to residents, streamlining service delivery and improving social inclusion.

South Korea's e-Government 2.0 builds on existing digital identity systems, like i-PIN, to enhance citizen authentication. Rwanda's Irembo Platform utilizes a digital ID system integrated with other services to provide citizens with a unique identification for accessing government services. Singapore's Smart Nation Initiative takes a unique approach, emphasizing SingPass as a single digital ID for citizens to access various government services and transactions. It also integrates biometric verification for secure access.

6.2 Data Security and Privacy

Estonia and Singapore prioritize data security and privacy through advanced technologies like blockchain and encryption. Estonia's X-Road platform uses blockchain to secure data, while Singapore adheres to stringent data protection principles. India's Aadhaar has faced debates and legal challenges regarding data privacy, emphasizing the importance of maintaining public trust in handling sensitive citizen data. South Korea and Rwanda also acknowledge the importance of data security but approach it in a context-specific manner.

6.3 Citizen-Centric Design and User Engagement

All case studies emphasize citizen-centric design principles to enhance user experiences. Estonia's e-Residency aims to provide seamless access for businesses and non-residents. India's Aadhaar enhances social inclusivity and access to government services. South Korea's e-Government 2.0 incorporates AI-driven chatbots to improve citizen interactions, while Rwanda's Irembo Platform offers various services online, reducing the need for in-person visits. Singapore's Smart Nation Initiative focuses on smart city solutions to address urban challenges, promoting convenience and livability.

6.4 Policy Frameworks

These cases operate within distinct policy frameworks. Estonia's digital-first governance is founded on transparency and a secure digital environment. India's Aadhaar aligns with the "Digital India" initiative to empower citizens through digital technologies. South Korea's e-Government 2.0 is part of "Government 3.0," emphasizing data utilization and smart governance. Rwanda's Irembo Platform is part of broader initiatives to digitize services and improve efficiency. Singapore's Smart Nation Initiative focuses on digitalization and collaboration across sectors for a smarter, more connected city.

6.5 Key Insights

- **Digital Identity is Fundamental:** Robust digital identity solutions are foundational for secure, efficient e-Governance. These initiatives streamline access to services and enhance security.
- **Data Security is Non-Negotiable:** Maintaining data security and privacy is paramount for maintaining public trust and upholding legal and ethical standards.
- **Citizen Engagement and Convenience Matter:** User-centric design and citizen engagement are central to the success of e-Governance initiatives. Convenience and accessibility drive citizen adoption.
- **Adaptation to Context:** These case studies demonstrate that e-Governance initiatives must be adapted to unique contexts, including the technological landscape, policy priorities, and societal needs.

In summary, these case studies collectively emphasize the importance of digital identity, data security, citizen engagement, and adaptability in e-Governance initiatives. They offer valuable lessons for governments worldwide seeking to harness digital technologies for more efficient, citizen-centric, and secure governance.

7 Conclusion

This paper presented a comprehensive analysis of the impact of digital technologies on e-Governance, illuminating a dynamic landscape where innovation intersects with governance, leading to transformative changes. Through an exploration of key themes, an examination of diverse case studies, and a comparative analysis of digital technologies, this research has made several significant contributions to understanding this critical intersection.

First and foremost, this analysis underscores the significance of digital identity initiatives in reshaping e-Governance. Estonia's e-Residency program and India's Aadhaar system showcase how robust digital identity solutions facilitate secure and convenient access to government services for residents and non-residents. These case studies contribute to understanding digital identity's foundational role in modern governance.

Furthermore, the emphasis on data security and privacy resonates throughout the case studies. Estonia's use of blockchain technology, India's ongoing efforts to address data privacy concerns surrounding Aadhaar, and Singapore's commitment to stringent data protection principles all highlight the critical importance of safeguarding citizen data in e-Governance initiatives.

Additionally, the central role of citizen-centric design and user engagement emerges as a common thread across the case studies. South Korea's AI-driven chatbots, Rwanda's Irembo Platform, and Singapore's Smart Nation Initiative emphasize prioritizing user experiences and citizen engagement in digital governance efforts.

The case studies collectively underline several key implications. They emphasize the fundamental role of digital identity in providing secure and streamlined access to government services. Simultaneously, they highlight the non-negotiable importance of data security and privacy for maintaining public trust in digital governance initiatives. Finally, the emphasis on citizen-centric design underscores the importance of convenience and accessibility in driving citizen adoption of e-Governance services.

As we look ahead, three promising avenues for future research emerge:

- Further exploration into digital technologies' ethical and legal dimensions in e-Governance is warranted. Understanding the intricate balance between innovation and safeguarding citizens' rights and privacy is paramount.
- In an era of rapid technological evolution, research should focus on forecasting the implications of emerging technologies, including quantum computing, 5G, and AI, on e-Governance.

– Comprehensive studies on the long-term sustainability and adaptability of e-Governance models in a continuously evolving digital landscape will be instrumental in shaping resilient and responsive governance systems for the future.

In essence, this research not only deepens the understanding of the transformative impact of digital technologies on e-Governance but also offers a roadmap for policymakers, practitioners, and researchers to navigate the complexities and seize the opportunities presented by the digital age of governance. By fostering inclusivity, transparency, and ethical practices, digital technologies can usher in an era of governance that is efficient and truly citizen-centric.

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Information Technology Adoption and Managerial Improvisation Capability: A NeuroIS Perspective

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Abstract. Managerial adoption of information technology and consequent value appropriation has been a matter of academic research interest for many decades. This short paper draws on varied streams of academic literature such as IS strategy and capabilities, neuroscience of musical improvisation, NeuroIS, and neural correlates of technology adoption to propose a novel NeuroIS-based approach to differentiating between various managerial capabilities, and specifically providing a neural basis for managerial improvisation capability. This study can potentially contribute significantly towards demonstrating the existence of managerial improvisational capability at play in organizations and highlighting the role of information technology adoption in the development of improvisational capability in managers.

Keywords: Technology adoption · Managerial improvisation · NeuroIS

1 Introduction

The volatile, uncertain, complex, and ambiguous (VUCA) of the present-day business environment requires specific managerial capabilities to stay competitive. Prior research has noted the role of information technology (IT) in helping managers develop these capabilities such as strategic agility [1]. The impact of IT on various outcomes has been widely examined in extant academic literature. However, scholars have recently noted that there is a need to further examine the value added by IT at the managerial level [2].

Prior academic research has conceptualized and examined the impact of IT on capabilities such as managerial ambidexterity [2], managerial dynamic capabilities [3], managerial sensing capability [4], and managerial absorptive capacity [5], among others. We focus on the role that IT can play in helping shape the improvisational capability of managers.

Improvisation may defined as "… the conception of action as it unfolds, drawing on available material, cognitive, affective, and social resources" [6]. Prior research has

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examined improvisation at various levels of analysis – individual, interpersonal, as well as organizational [7, 8]. The role of IT in facilitating improvisation is well documented at the organizational level [9–13]. Prior research has distinguished between dynamic capabilities and improvisational capabilities in the context of new product development [9], concluding that the nature of the environmental change determines the utility of these capabilities for organizations.

While a majority of such studies are concentrated at the organizational level of analysis, some scholars have begun examining the role of IT and digital technologies in enabling and facilitating improvisation at the managerial level [14–16]. This capability is indispensable in ensuring that managers can sense and seize the relevant opportunities before their competitors. Prior research identifies three broad categories of managerial improvisation – *bounded managerial improvisation*, *discovery managerial improvisation*, and *full-scale managerial improvisation* [16].

The extant research on IT and managerial improvisation has identified enabling capabilities such as a flexible IT infrastructure, a well-developed information management capability, organizational memory, the competitive environment and the design of the organization [16]. However, we argue that there is a scope to extend this work in two key aspects – (a) identification of more antecedents (both IT and non-IT related) and consequences (both IT and non-IT related) of managerial improvisation capability, (b) utilize research methodologies apart from qualitative case studies and surveys.

The IS strategy literature has focused on developing capabilities to execute daily activities (operational capabilities), engage in planned reconfiguration (dynamic capabilities), and spontaneously respond to surprising changes (improvisational capabilities) [9, 17]. Despite the theoretical distinction among these three capabilities, it is not clear whether they correspond to how organizations function. The distinction between dynamic and improvisational capabilities is still an unsettled issue in the literature [18]. In that neurophysiological tools can localize the neural correlates of human activities; it would be very possible to examine where spontaneous improvisation occurs in the brain and if it differs from planned change. In doing so, neurophysiological tools could help resolve debates in the IS strategy literature that could not be easily examined otherwise. In this context, [19] note how organizational cognitive neuroscience can help us deepen our understanding of how decisions are made by managers. Hence, we use the following research questions to drive this study:

- *What is the impact of information technology adoption on managerial improvisation capability?*
- *Can the adoption of a NeuroIS perspective help us extend our current understanding of the relationship between information technology adoption and managerial improvisation capability?*

2 Literature Review

2.1 NeuroIS

NeuroIS is an emerging stream of information systems (IS) research which seeks to leverage tools and knowledge developed in the neuroscience domain to better understand and examine IS issues such as adoption and use of technology, electronic commerce

and trust, decision support systems, and others [20]. Right from its genesis in 2007, NeuroIS seeks to use tools such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) to measure nervous system activity, and thus measure neurophysiological processes.

Extant NeuroIS research has examined key IS issues such as belief in fake news on social media [21], information processing in electronic networks of practice [22], processing of multidimensional visualizations [23], violations of information security policies [24], perceived trustworthiness of Ebay offers [25], information processing biases in virtual teams [26], social influence in group buying [27], learning experience in a computer-based instructional environment [28, 29], decision to download an app [30], virtual shopping [31], formation of website impressions [32], role of priming in electronic brainstorming [33], tendency of individuals to pay lower attention to security warnings over time [34], cognitive processes underlying the understanding of conceptual models [35], improvement of emotion regulation [36], self-control in information security violations [37], trust in avatars [38], beliefs of users in information systems [39], understanding and assessment of emotions [40], equilibrium seeking in online search [41], and the protection of information privacy [42].

2.2 Improvisation

One of the earliest models in the context is Pressing's model [43, 44] which contends that improvisation is an acquired skill that can be acquired and enhanced by training. Expertise in improvisation draws on the interplay between referent processes (cognitive / perceptual / emotional) and domain-specific knowledge. Over time, the improviser can minimize the gap between intended and actual performance by drawing on perceptual feedback to correct errors. Thus, improvisation can be seen as a series of generative and evaluative processes. Recently, Zenk and colleagues [45] have provided a systems model for improvisation, which identifies *core* factors and *impact* factors associated with improvisation.

The IS improvisation model was proposed by McGann [46] and depicts the interplay between IS use and IS design contexts, and how planned and emergent change ultimately results in permanent change. The model tries to capture how the crossing of the boundaries between design and use contexts helps improvisational processes achieve permanent organizational change. Also, improvisations evolve from ad-hoc adjustments to embellishments and / or modifications and ultimately to a metamorphosis.

2.3 Neuroscience of Improvisation

A few scholars have examined the neural underpinnings of certain activities involving improvisation, most notably music and specifically jazz. This has led to the emergence of a novel field termed *improvisation neuroscience* [47], and most of the work has centred around the identification of cognitive processes and the elucidation of neural substrates involved in musical improvisation [48–51].

Extant scholars have conducted empirical studies to identify the brain areas involved in improvisation, in the musical context [49]. The DLFPC (dorsolateral prefrontal cortex) is a brain region that sits just behind the forehead and plays a central role in the

process of cognitive control, and it shows strong deactivations during musical improvisation. The MFC (medial frontal cortex) comprises the ACC (anterior cingulate cortex), SMA (supplementary motor area), and the pSMA (pre-supplementary motor area), and is activated during musical improvisation activities. The ACC, SMA, and the pSMA are involved in selection and sequencing of plans during musical improvisation. The rPFC (rostral prefrontal cortex) is a region of the brain located just above the eyes and shows focal activation in professional jazz musicians with high levels of musical freedom and little constraint. rPFC activity is usually associated with internally generated thoughts and actions, and the integration of higher-order goals with current task rules. Finally, the Broca's area / IFG (inferior frontal gyrus) and the Wernicke's area / pSTG (posterior superior temporal gyrus) shows enhanced activation during spontaneous musical interactions which characterise improvisational activities.

3 Methodology

The use of neurophysiological approaches and tools such as fMRI and EEG has become quite popular in various domains of management, including but not limited to prediction of advertising success [52], consumer behaviour [53], differentiation between transformational and non-transformational leadership [54], exploration-exploitation and attention control [55], cognitive flexibility and adaptive decision-making [56], and others.

NeuroIS has recently emerged as an established subfield of information systems research [20] aiding the use of neurophysiological tools by IT scholars. The reasons for our use of the NeuroIS perspective for exploring the underlying dynamics of IT-enabled improvisational capability of managers is threefold. First, neuroscientific tools can provide more comprehensive and unbiased measures of IS constructs than traditional instruments, such as surveys [57]. Specifically, NeuroIS can help examine if the brain activations due to the use of IT can help predict certain outcomes or consequences (in this case, managerial improvisation). Second, neuro-scientific tools can help to "triangulate different measurement methods and data sources, and thereby strengthen the robustness of empirical IS studies". In this regard, NeuroIS can bring out different dimensions of a phenomenon using multiple data sources. Third, neuro-scientific studies of improvisation in the context of music have already been conducted [47, 58]. It can be expected that the objectivity of measures could be extended and associated neural processes correlated to IT-enabled improvisation in a managerial context.

4 Expected Contributions

This study has the potential to make several contributions. First, it can add to extant academic literature on the business value of IT at the managerial level. By showing how IT can help develop a managerial improvisation capability, this study can extend our understanding of IT-enabled capabilities and consequently the business value of IT. Second, this study will contribute to our current understanding of the scope of NeuroIS as a research approach, by using this methodological approach to address a research problem situated at the confluence of IT and strategic management. Third, this study can

add to our understanding of the antecedents of managerial improvisation, by introducing IT as an important enabler.

Since improvisation is arguably an important managerial capability particularly in highly turbulent business environments, this paper also potentially contributes to managerial practice by seeking to demonstrate how the use of IT can be beneficial for managers seeking to engage in improvisational activities for the benefit of their respective organizations.

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Metaverse and Marketing

Metaverse Adaptability in Theory Context

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Abstract. This article aims to shed light on the usage possibility of the decomposed theory of planned behavior in the Metaverse to understand consumer behavioral intentions toward the metaverse better. The current research addresses the following questions. (1) How DTPB aids in metaverse adaptation. (2) Study scope and following research based on the findings. The current study questions the best determents of consumer attitudes to adapt Metaverse as a unidimensional or multidimensional. This opinion paper proposes directions for future studies that support the usage of decomposed constructs for a comprehensive understanding of consumer attitudes toward the adaption of Metaverse.

Keywords: Metaverse · decomposed theory of planned behaviour · opinion paper · marketing · adaptability

1 Introduction

The word Metaverse was first used by Neal Stephenson in his science fiction book Snow Crash in 1992. "It consists of the stem verse, which means world and universe, and the prefix meta, which stands for transcendence and virtuality." In the metaverse, known as accurate-time virtual worlds, many users can engage in social, economic, and cultural activities and communicate through avatars and their surroundings without being physically present (Wu & Ho 2022). Even though the metaverse was first established thirty years ago, little has changed. This results from the technical difficulties in the coordination, communication, and shared understanding processes (Anderson et al. 2022). Various industries were the first to adopt the metaverse, including healthcare, e-commerce, and hospitality (Azar et al. 2022; Lee et al. (2021). Recent studies gave a view about the future agenda of the metaverse as well as its implications, especially in the healthcare sector.

This article investigates the applicability of the decomposed theory of planned behavior (DTPB) in the Metaverse context. The current research aims to answer the following questions.

(1) How does DTPB help in adapting the metaverse? (2) Scope and future studies based on the results? At first, the author briefs about the current marketing topic and explains the article's flow in the introduction. Secondly, between the previous study

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covered in the literature, metaverse features and challenges. Next, theoretical background about the theory used. Finally, the author will provide the conclusion and limitations for future studies.

2 Literature Review

Studies on the metaverse have drawn the most interest over recent years. Several significant factors influencing customers' intentions to use this platform have been found and confirmed (Dwivedi et al. 2022; Tan et al. 2022); the potential for a digital transformation and the quick development of new technologies demand that governments keep up. Many sectors started adopting the metaverse to emerge with the new trend in Information technology, marketing, education, tourism and hospitality, psychology, and other academic disciplines (Dwivedi et al. 2022a; Lee et al. 2021). Global technology giants and start-ups are investing quickly in digital health research and development. For example, Thomason (2022) pointed out that the new approaches to gauge the effectiveness of health interventions in real time are made possible by the increased usage of wearable technology, mobile phones, and smartphones. Hence, the pharma and biotech industries are increasingly reliant on digital technologies. For the government, business titans, and the general public, digital literacy has become a crucial ability.

Although in its infancy, marketing studies on the metaverse are expanding quickly in several subfields, including advertising, luxury, retail, sales, and branding. The retail sector has the most substantial number of workers. Fashion brands are leading the way, including masstige and luxury brands which may pave the road for lower-end retail brands in the metaverse prospect (Wang et al. 2022). Earlier studies examined online/digital marketing adoption in developed and developing nations. Many different elements have been researched, and many ideas have been formed (Abbasi et al. 2021; Barnett et al. 2015; Ho et al. 2020). Three frameworks, "the Diffusion of Innovation (DOI), Technology Acceptance Model, and Decomposed Theory of Planned Behaviour (DTPB)," are the most employed to describe consumer intention to adopt novel technology. Although these broad-spectrum ideas and frameworks have been used in numerous studies, it is essential to consider consumer and innovation-related attributes when creating research models. This article aims to help readers get a more precise knowledge of the applicability of the decomposed theory of planned behavior in the Metaverse context of consumer psychology. The article also seeks to pinpoint the features of the metaverse and the key challenges that service providers must surmount from the viewpoint of the public in order to hasten the adoption of metaverse technology.

2.1 Metaverse Features

Metaverse is "a hybrid of extended reality, non-fungible tokens (NFTs), decentralized governance, and cloud services, with self-sovereign identity facilitating the exchange of physical, economic, and content assets" (Thomason 2022). The term metaverse "refers to a new version of the internet that combines the real and virtual worlds through the use of avatars, blockchain technology, and virtual reality headsets" (Lee et al. 2021). AR and VR usage activity initiated by some companies, such as the virtual worlds and immersive

video games, including Second Life, Fortnite, and VRChat, has been referred to as the forerunners of the metaverse and provide some context for the possible socioeconomic effects of a fully operational persistent cross-platform metaverse (Dwivedi et al. 2022). However, on the other side, other researchers argued about the falsity of the metaverse and the long duration it will take to be fully implemented, not just as a vibe for a short period (Golf-Papez et al. 2022). This research looks at these points from a consumer standpoint. These viewpoints cover a variety of metaverse marketing subjects, containing potentials and difficulties, consumer awareness, sociological and psychological ramifications, and so on.

2.2 Challenges

Aside from the most asked question of whether the metaverse is like a massive vibe that will fade with time, interested people researchers must address many issues. The metaverse proposes a prosperity of creative marketing perspective but presents many unexpected market hindrances. Perhaps we should take a step back and consider whether this is simply another Second Life that is entertaining for a while before dissipating before we become tied up in the metaverse as a substitute universe (Belk et al. 2022). Even though the early platforms were formed to provide a virtual experience, they were believed to be distinct from experiencing reality. Prior to the metaverse, platforms focused the development efforts on specific interest groups. Decentralized stages that study real-world exchanges in the metaverse provide delicate outcomes while aiming to uphold norms of decency among all age groups. The metaverse enlarges brands and platform businesses that deal with numerous technical and infrastructure alarms. The interface must be simple while building a multicultural metaverse and consider consumers' social backgrounds (Hughes et al. 2022b). The current study investigates the challenges and obstacles consumers face to adopt innovation from the DTPB context. Due to the uncertainties surrounding consumer communications and behavior in the metaverse, there are socio-cultural complications. Marketers must grasp consumer favorite content usage trends. Marketers should investigate ways to facilitate participation in the platform, as not all consumers can join for many reasons, such as lack of skills and money (Dwivedi et al. 2022). When consumers perceive a technology to be easy to use, his/her preference will most likely be favorable toward this technology (Vahdat et al. 2021). Affordability and accessibility are some of the main issues a consumer faces. The headset of VR and AR have a very high price that not all consumers can afford, which limits the accessibility of the number of users or customers to the platform. Consumers fear leakage of personal data. Privacy is the primary concern of the users. Marketers should ensure the security of personal data as the metaverse can access critical data of the users even through its avatar.

3 Theoretical Framework

The DTPB evolved from the well-known theory of planned behavior (TPB) by Ajzen (1991), where it self-evolved from the reason action theory (TRA) by Ajzen and Fishbein (1975). The TPB is known for its high use in predicting the consumer intention to buy a

product or adopt an action. According to TRA, attitude and subjective norms are functions of behavioral intention. To account for circumstances where a person has less than total control over the behavior, a perceived behavioral control (PBC) is added to the TPB model. The theory covers the cognitive part, containing three key elements: "Attitude (AT), subjective norms, and perceived behavioral control." The theory has been proven for its efficiency in predicting consumer behavior. Behavioral intention was defined as "an indication of how hard people are willing to try, of how much effort they are preparing to apply, to do the activity" by Ajzen (1991). According to the TPB, people's beliefs, attitudes, and intentions play a role in determining their behavior. Particularly, important determinants of a person's behavioral intent include subjective norms, attitudes toward the behavior, and perceived behavioral control. Decomposing outcomes into distinct dimensions and predicting and explaining human conduct across various platforms are successful uses of the decomposed TPB model. According to research, leaders and marketing managers can use the decomposed TPB model constructs as a comprehensive tool to identify usage behavior, intention, and adoption toward system deployment. The decomposed TPB model is an integrated model comprising the TAM, pure TPB, and decomposed TPB models. Moons and De Pelsmacker (2015) claim it is superior to the TAM model. Despite this, the decomposed TPB model offers a comprehensive examination of usage behavior and intention and is a better resource than TAM for those looking for solutions in the area of system development (Taylor & Todd 1995). Emotional components are usually left out of TPB models. While moral sentiment is playing a bigger role in the advancement of contemporary civilization. Highlighted the lack of research that had been done on the subject. Emotions are typically categorized into "positive" and "negative" categories. Additionally, a vast array of literature on consumer behavior based on TPB is available and is highly predictable. The deconstructed TPB model was developed to get around TPB's constraints (Rogers 1983; Taylor & Todd 1995). It uses ideas from the diffusion of innovation theory. Perceived utility and simplicity of usage can be used to gauge attitude. Perceived ease of use (PEOU), similar to complexity, is the first sub-dimension. It is "the degree to which a person believes that using a particular system would be free of effort" (Davis 1989, p. 320). Relative advantage, the word used to describe perceived usefulness (PU), the second sub dimension, is analogous and means "the extent to which a person believes that using a particular system would enhance his or her job performance" (Davis 1989, p. 320). Self-reported usage is significantly correlated with perceived usefulness and ease of use. PBC seems to consist of two parts. Facilitating conditions (FC), which depict the accessibility of resources required to engage in a behavior, comprise the first component. This could entail having access to the required time, money, or other specialized resources to engage in a behavior. The next factor is self-efficacy (EF), or a person's belief in their capacity to act. A person's underlying attitudes about the outcomes of their behavior can also be used to explain attitude. Second, subjective norms (SN) are the outcome of one's feelings regarding the perception of their behavior by others (including family, friends, and co-workers) and the significance placed on it personally. These results from two fundamental underlying causes: the desire to act according to the expectations of important people and the normative views that one attributes to these people. Several academics have looked at methods

for breaking down beliefs into multidimensional constructs in demand for better comprehension of the connections between belief structures and the antecedents of intention. The rationale behind employing a modified deconstructed TPB model is to prove that consumers intend to use metaverse rather than test their adoption. Additionally, Pedersen and Ling (2003) especially stress that conventional adoption models, such as the deconstructed TPB model researched in an information systems environment, can be altered when used for adoption services (Balabanoff 2014). When compared to unidimensional belief structures, a decomposition technique has various advantages. The antecedents of intention are not likely to be consistently tied to monolithic belief structures that represent many dimensions. By breaking down beliefs, such connections should become more obvious and understandable, pointing to elements that might impact behavior. The decomposition can also provide a consistent set of beliefs that may be used in several contexts. This solves operationalization issues with the conventional intention models that have been noticed.

3.1 DTPB Implications

The diffusion of innovation theory is extensively applied to research the variables that affect a person's choice to accept an innovation or technology. According to the DOI model, "people would only adopt a technology if it exhibited the following five qualities: relative advantage, compatibility, complexity, observability, and trialability" (Rogers 1983). The "Technology Acceptance Model (TAM) was created to gauge consumer intention to use, but it took into account how attitudes are influenced by perceived usefulness and perceived ease of use" (Davis 1989). This model is pretty much like the DOI model. Perceived usefulness is a notion comparable to "relative advantage," in the current study, perceived usefulness is employed in place of relative advantage. Additionally, "perceived ease of use" is used in place of "complexity" (Ho et al. 2020). To overcome the challenges mentioned above, the author chose to study the effectiveness of DTPB. We noticed from the above literature that consumer attitude depends on various elements to make consumers prefer the platform. The DTPB offers a more thorough comprehension of behavioral intention in addition to DOI and TAM.

1. Attitude toward the adoption of metaverse

Perceived ease of use and perceived usefulness are the attitude beliefs in the decomposed theory of planned behavior based on TAM (Davis 1989). As a result, in this study, the technology acceptance model's technological belief variables—perceived usefulness and perceived ease of use—comprise attitude. The anticipation of a person's effort towards a specific technology is known as perceived ease of use. Reducing the effort needed to utilize a system can encourage users to use it more frequently, which boosts performance. This study defines perceived ease of use as the degree to which a person thinks using metaverse can be quickly accessed and is a straightforward, not-difficult activity. In technology-related studies, the variable of perceived usefulness is a crucial element that influences acceptance intention. The extent to which a customer believes that using the Internet and cell phones would enhance the functionality of the metaverse (Dwivedi et al. 2022; Giang et al. 2023).

It refers to the extent to which a person thinks using online retailers over brick-and-mortar stores would produce relatively more promotional benefits, such as price savings (Davis 1989). The degree to which one believes that using the Internet and smartphones in the metaverse will have the desired effects is defined as perceived usefulness in the current study.

Hypothesis 1: Perceived usefulness of using metaverse positively affects customer's attitude toward metaverse.

Hypothesis 2: Perceived ease of use of metaverse positively affects consumer's attitude toward metaverse.

Hypothesis 3: One's attitude toward the metaverse positively affects one's intention toward adopting the metaverse.

1. Subjective norms

According to Fishbein and Ajzen (1977), a subjective norm is a person's view of what his peers think about whether the conduct in question is desirable. SN proved more significant in the early phases of innovation execution (Ho et al. 2020). It relates to intention since people frequently behave according to how they believe others should behave (Ho et al. 2020; Jouda et al. 2020; Yeow & Loo 2022).

Hypothesis 4: Subjective norms positively affect one's intention toward adopting the metaverse.

2. Self-efficacy, facilitating condition, and perceived behavioral control

Perceived behavioral control describes a person's perception of opportunities and how they will help or impede them in using technology. Self-efficacy and enabling situations are the two factors that affect perceived behavioral control (Taylor & Todd 1995). Self-efficacy is a term used to characterize a person's confidence in their ability to accomplish (Bandura 1977, 1982). Self-efficacy is a credible construct in predicting intent to use technology items (Dezdar 2017; Dwivedi et al. 2019). As a result, tech-adept people are more likely to accept the metaverse. The availability of resources to carry out or participate in the behavior is referred to as the facilitation of conditions (Alrawashdeh 2012). In the context of the metaverse, enabling conditions can be divided into specialized resources like accessibility, speed, and associated costs (Taylor & Todd 1995).

Hypothesis 5: Self-efficacy has a positive influence on perceived behavioral control.

Hypothesis 6: Facilitating condition has a positive effect on perceived behavioral control.

Hypothesis 7: Perceived behavioral control positively affects one's intention toward adopting metaverse (Fig. 1).

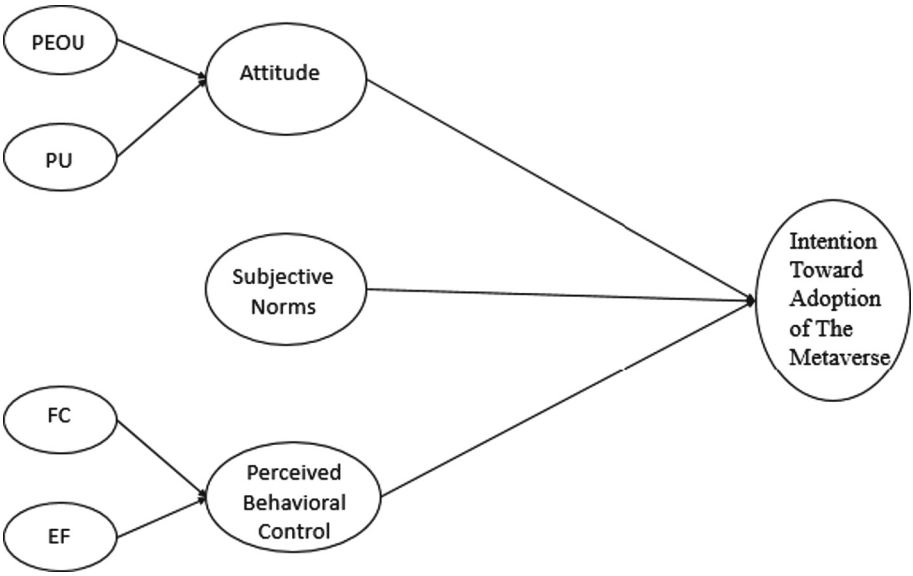

Fig. 1. Research Framework

4 Discussion

Customers are accepting digital goods to become more technologically adaptable. The enthusiasm surrounding the metaverse in business is an excellent example of its marketing potential. The metaverse can provide an immersive experience compared to conventional and digital platforms. Therefore, marketers can use the metaverse to create digital value, including shopping, branding, advertising, and more. From a comprehensive standpoint, the metaverse could be a medium with value added to the client purchasing process (Dwivedi et al. 2022). Studying the attitudinal behavior of a customer for adapting the new technology was better explained by decomposed attitude—the widespread use of the metaverse has profound marketing ramifications that provide new tiers of customer engagement. Decision-makers face numerous obstacles about the scope and timing of their expenditures and how they might modify the business models to offer tangible remunerations (Hofstetter et al. 2022; Tan et al. 2022).

5 Conclusion

To progress in many aspects of the technology adoption trends, researchers must develop a deeper understanding of attitudinal and behavioral aspects of user adaptation practices. The theory of planned behavior served as the foundation for this study, and to differentiate it, we added the elements of belief in technology adoption and the elements of emotion that are crucial to emotional variables. Previous research did not consider cognitive, emotional, or technical elements jointly. In order to better comprehend the behavioral intentions of metaverse users, we approach the decision-making process from

the standpoint of technological acceptance. This study explained why using the decomposed theory of planned behavior is crucial in a metaverse context. The advantages of exploring the attitude of users in multidimensional aspects have proven to be better, especially when interpreting it in TAM constructs. Furthermore, the current study addressed the metaverse's features and challenges, which highlighted an association with adapting the metaverse from trust, privacy, and cyber security. However, the advantages of adapting to new technology get more light as the literature pointed out the significant metaverse usages in different fields and its crucial role in enhancing healthcare, brand creativity, and connecting with consumers at a personal level.

Theoretical and Practical Implication

In the context of the metaverse, intention, attitude, subjective norms, and PBC were the elements that influenced how people integrated technology into their behavior. Though the intention was a factor that was ignored, it was only directly related to behavior in DTPB. The causes of it could be the subject of future investigation. Users' emphasis on self-efficacy, individual influence, and conducive settings demonstrates that these elements must be directly rather than indirectly related to intention towards behavior. An empirical analysis of the behavior might be conducted in a similar setting. However, various data-gathering strategies could be used to examine the conduct during the adaptation process, including observation and user perceptions of metaverse behavior following mentoring.

Metaverse users can occasionally experience difficulties. Users have difficulties both during and after receiving technology mentoring, including a lack of time and motivation, inadequate technological understanding, and privacy issues. Enhancing opportunities (creating a support office, assigning departmental troubleshooting staff, holding seminars, offering more technical opportunities) and encouraging integration behavior (extrinsic motivation, extra promotion) could aid them in deepening their understanding of technology and overcoming obstacles. The findings point to ways to enhance the metaverse implementation process, raise user awareness of technology adoption, and give users more time and incentives to do so.

Limitations

Numerous vital marketing topics in the metaverse have been covered in this research from various angles using the decomposed theory of planned behavior. The current research outlined a future research agenda as a checklist for more research. Upcoming research is encouraged to expand on these suggestions by using a variety of alternate methodological techniques (experimentation, case studies, and mixed approaches) to record and examine the wide range of elements that help to illuminate how the metaverse could be advantageous for marketing, value creation and consumer wellbeing, branding, and services. It is crucial to conduct additional academic research on how businesses can function in the virtual world. However, this work must be balanced with studies into the various ethical, behavioral, and adverse effects on different users.

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Unlocking Metaverse Flow Experience Using Theory of Interactivity and User Gratification Theory

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Abstract. The study aims to examine and identify the important antecedents and consequences of Metaverse flow experiences, leading to user gratifications and purchases on the Metaverse platform. The study used the theory of interactivity integrated with user gratification theory to investigate purchases on Metaverse. 379 responses received through the online survey were analysed through structural equation modeling. The study found that interactivity made of Metaverse design characteristics and User interactivity, Metaverse augmentation made of Wearable devices and Avatars lead to a flow experience. The study also validated that metaverse flow induced hedonic gratification for metaverse purchases. However, the study refuted the influence of flow experience on utilitarian gratification and purchase. The study makes a novel input to the existing literature on consumer behaviour concerning metaverse purchases. Marketers can gain insight from our study regarding the metaverse flow factors that stimulate hedonic and utilitarian gratification, thereby increasing purchases through the metaverse platform.

Keywords: Metaverse media · Flow experience · interactivity · augmentation · hedonic gratification · utilitarian gratification · metaverse purchase

1 Introduction

The idea of the metaverse has recently acquired prominence, and the retail sector has seen many application scenarios. Retail-related metaverse-like experiences are now being tested by businesses and platforms to improve product visualization, customized shopping experiences, virtual try-ons, and create virtual showrooms (Dincelli, and Yayla 2022). Online marketplaces that mimic real-world retail settings are made using virtual surroundings, allowing users to connect socially while exploring products and making purchases. Virtual reality experiences are used in marketing and advertising, including immersive brand storytelling, interactive product demos, and virtual reality-based advertising campaigns (Wongkitrungrueng and Suprawan, 2023). Consumer attitudes, perceptions, purchase intentions, actions in virtual retail environments, consumer intelligence and context awareness are emerging areas of research. Metaverse allows users

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resemble a digital avatar that influences purchase intentions, and this relationship may be mediated through flow experience.

Metaverse media employs virtual reality (VR) to enhance fictitious realities, along with augmented reality (AR) to add visual elements, sensory elements, and music, to physical-world settings. Users in the Metaverse will be able to immerse themselves in a setting where the physical and digital worlds intersect rather than only seeing digital material. Many brands like Nike and Gucci have used metaverse marketing in their advertising efforts and are leveraging lucrative new markets and profiting from customer loyalty.

Live shopping events have been found to significantly influence virtual item purchases by raising engagement rates with location information (Nica et al. 2022). Metaverse provides a differentiated experience by providing a unified and immersive reality created using synthetic elements that are false yet essential for capturing customers (Golf-Papez et al. 2022).

Previous studies show that perceived media richness leads to cognitive and affective trust, and this will impact purchase intention on Metaverse (Zhang et al. 2023). Stimulus-response-organism (SOR) theory was used to find the impact of effectiveness, interactivity, and vividness on purchase intention (Jafar et al. 2023). Features of retail experience characteristics through metaverse application features have an impact on purchase intention (Patil et al. 2022). No study addressed the impact of metaverse media interactivity and augmentation on metaverse flow and users' gratifications thereby increasing metaverse purchase behaviour. Therefore, this study intends to find the factors that impact metaverse purchase intentions and also investigate the mediating effect of metaverse flow experience on purchase intention.

1.1 Research Question and Objectives

The study tries to answer which are the important features to generate Metaverse flow experiences and explain how and why flow influences consumers' gratifications, as well, as purchasing behaviors in the metaverse. The study objectives are: i) To explain how Metaverse design, User interactivity, Wearable devices, and Avatars, lead to Metaverse flow experiences. ii) To study how the Metaverse flow experience influences users' gratifications, and the metaverse purchase. The findings of the study will facilitate retailers and metaverse platform designers to understand the antecedents and consequences of metaverse flow experience and its significance in consumer purchase decisions.

2 Literature Review

The theory of interactivity (ToI) and user gratification theory (UGT) are used as underpinning theories for the model.

2.1 Theory of Interactivity

In the business context, interactivity means the "combination of rich content, active intelligence, and collaborative communications to create a compelling consumer experience". The quantity and variety of interactive features present in the virtual world can

be used to objectively evaluate this form of interaction (Voolverld et al. 2011). The theory of interaction covers many facets of human-computer interactions, such as cognitive, emotional, social, and behavioral components. It highlights the mutually beneficial relationship between users and technology, where users can take the initiative and receive feedback to help them shape their interactions in the future (Sundar et al. 2015).

2.2 User Gratification Theory

The Uses and Gratification theory (U&G) examines how people utilize the media to promote their own needs and feel happy when those needs are met (Katz et al. 1973). The idea can be used to analyze why individuals interact with the metaverse and what they want to gain from it in the setting of the metaverse. Previous research on virtual reality has revealed that factors including enjoyment, social interaction and sharing, challenge and achievement, convenience, and informativeness are reasons people utilize it (Hwang et al. 2022). The motivation for using the metaverse for business exchange activities depends on the metaverse's informativeness, engagement, and enjoyment. Previous study indicates users' hedonic and social pleasure was greatly impacted by the shopping experience and metaverse application characteristics (Patil et al. 2022).

2.3 Conceptual Model and Metaverse Flow Experience

This study has proposed a conceptual model integrating the Theory of interactivity with the users' gratification theory as given in Fig. 1.

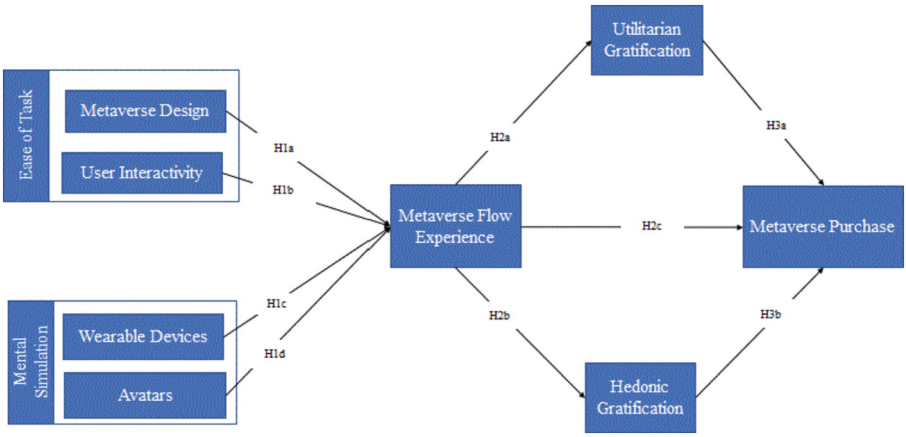

Fig. 1. Conceptual model for metaverse flow and purchase on metaverse

2.4 Metaverse Flow Experience

Control, responsiveness, exploration, connectivity, emotional connectedness, two-way communication, and playfulness were used to categorize the perceived interactivity

of the metaverse (Lee et al. 2021). The design of the metaverse has a considerable impact on the flow experience of users. Utilizing the flow theory, flow experience can be defined as "The holistic sensation that people feel when they act with total involvement"(Csikszentmihalyi 1975). Flow experience can be a mental state characterized by enjoyment, cognitive engrossment, and time dilation (Csikszentmihalyiet al. 2014). By reducing cognitive load and enabling users to traverse and engage with the metaverse with ease, an intuitive, responsive, and user-friendly user interface helps encourage flow. An increased sense of immersion can be facilitated by interesting sights, appealing sounds, and a sensation of presence.

Previous studies discovered that visual interactivity, one of the features of graphic simulation technology, substantially impacts customers' telepresence, which stands for immersive encounters that resemble flows (Mollen and Wilson 2010). "The degree to which the user perceives that the interaction or communication is two-way, controllable, and responsive to their actions" is the definition of perceived interactivity (Petersen et al. 2022). Customers, for instance, may view interactivity as a key media feature of the metaverse because it allows them to interact with the stimulus, alter the stimulus, and even share their images and experiences via social media integration (Pachoulakis and Kapetanakis 2012). The link between flow and repeat intention is positively moderated by utilitarian considerations (Liu, 2017). Vividness, interactivity, and telepresence enhance the flow experience. Media users are significantly more satisfied when they are in a flow state (Kim and Ko 2019).

In the metaverse, the level of immersion, usability, and overall engagement can be affected by the choice of devices that facilitate accessibility and interaction with the metaverse environment (Dwivedi et al. 2023). The sense of immersion and existence in the metaverse can be improved by using high-quality immersive technology like virtual reality (VR) headsets and haptic feedback devices. The processing speed, graphics rendering, and network connectivity of devices all have an impact on how snappy and fluid the metaverse experience is. A more inclusive flow experience can be made possible by the mobility and accessibility of devices, the ability to engage across numerous devices, and the introduction of accessibility features (Jafar et al. 2023). A previous study has validated that perceived interactivity affects cognitive, cognitive-affective, and affective perceptions (Cyr et al. 2009).

When users imagine their avatars to be like them, flow in the virtual reality environment improves (Davis et al. 2009). The degree to which users believe their avatar to reflect who they are or to be an expanded version of themselves is known as "user-avatar identification." Additionally, it was revealed in earlier studies that avatars with striking visual emotions enhance presence and flow (Dwivedi et al. 2023). According to research, avatars can make online sales channels more persuasive. Therefore, we hypothesize the following: H1a: Metaverse design characteristics have favourable effects on the metaverse flow experience. H1b: User interactivity has favourable effects on the metaverse flow experience. H1c: Wearable devices have favourable effects on influencing the metaverse flow experience. H1d: Avatars have favourable effects on the metaverse flow experience.

2.5 User Gratifications

Hedonic gratifications like enjoyment, affection, and imagination have been proven to influence user behaviour on social media (Li et al. 2015). The significance of utilitarian elements in driving user behaviour, such as immediate access, information sharing, and self-documentation, has been empirically confirmed (Liu et al. 2016). Therefore, online retailers must not only offer "flow opportunities" that increase the hedonic gratifications but also other tools and opportunities that increase the utilitarian gratifications. These higher levels of pleasure and arousal have a beneficial impact on flow, hedonic and utilitarian value, and patronage intentions.

Studies have shown that people in flow better assimilate information carefully, which improves cognition and therefore improves performance. Flow may result in more efficient utilitarian results. The favourable impact of flow on hedonic qualities, such as sensory images, playfulness entertainment, and intrinsic enjoyment, is strongly supported by the available research. Users experiencing improved presence and flow believe that the platform is more rewarding and delightful to use, which raises their perception of its hedonic value. Immerse experiences that create presence and flow also lead to utilitarian and hedonic values on user engagement (Rodríguez-Ardura et al. 2023). Using the uses and gratifications theory, flow influences customer satisfaction (Nanda and Banerjee 2020). Therefore, we hypothesize the following:

H2a: Metaverse flow experience favourably impacts users' utilitarian gratification. H2b: Metaverse flow experience favourably impacts users' hedonic gratification. H2c: Metaverse flow experience favourably impacts purchase behaviour on the metaverse. H3a: Utilitarian gratification favourably impacts purchase behaviour on the metaverse. H3b: Hedonic gratification has favourably impacted purchase behaviour on the metaverse.

3 Research Methodology

To investigate the proposed associations empirically, survey data were gathered from Millennials and Gen Z consumers who had explored Metaverse retail platforms or games. The respondents were from Pan India as it is an emerging economy that fuels an increase in goods and services consumption. The selected innovative, digitally-influenced, and proficient in technology young users were well educated, with good income, and aware of products on the metaverse platform. Customers were urged to use Metaverse Retail sites from Gucci Garden, Louis Vuitton, Burberry, and Nike before responding to our survey. Customers were questioned in a structured way regarding the retail metaverse platforms and the dimensions of the metaverse flow experience, resulting in gratifications impacting their purchase decisions. Respondents' responses, were collected through purposive sampling.

3.1 Measures

Eight constructs from previous studies were modified into question items for the survey instrument to be scored on a 7-point Likert scale. The survey instrument created by

the researchers included demographic data. four items for Metaverse design aesthetics (Lavie and Tractinsky 2004), five items for user interactivity (Liu, 2003), three items for wearable devices (Cuevas et al.2021), and four items for Avatar (Liu, 2003), four items for Metaverse flow experience Csikszentmihalyi, 1975; Novak et al. 2000). Voss et al. (2003) and Lee et al. (2021) contributed to 10 items for measuring consumers' utilitarian and hedonic gratification. To gauge consumer purchase on metaverse retail, three items from Venkatesh et al. (2003) were modified.

3.2 Data Collection

The "10-times rule" method is used to calculate the minimal sample size in PLS-SEM (Hair et al. 2021). Out of 450 responses received, 71 incomplete surveys were eliminated to get a final sample of 379 (response rate: 84.22%). Structural equation modeling using SmartPLS tools can provide sufficient power for small sample sizes (Hair et al.2021). Information on customer demographics is provided in Table 1.

Table 1. Demographics of Online Consumers

Demographics		Frequency	Percentage (%)
Gender	Male	203	54%
	Female	176	46%
Age	22–25	124	33%
	23–25	147	39%
	25–27	66	17%
	28–29	42	11%
Shopping Frequency	Once a month	117	31%
	Twice a month	161	42%
	More than Twice a month	92	24%
	None	9	2%

4 Data Analysis

PLS does not estimate all model relationships at once, therefore it is possible to estimate complex models with small sample sizes (Henseler et al. 2014).

4.1 Measurement Model Assessments

As per Table 2, Cronbach's alpha coefficients were verified to find the reliabilities of measurement items to be greater than 0.7, demonstrating satisfactory internal consistency (Hair et al. 2021). Convergent validity for each construct was accepted because all

factor loadings were > 0.70 and statistically significant. All constructs had Average Variance Extracted (AVE) values larger than 0.5 and composite reliability values greater than 0.7, both of which were above the cutoffs (Hair et al. 2021). According to the criterion established by Fornell and Larcker (1981), the AVE was higher than the squared correlation between each pair of constructs confirming the discriminant validity.

Table 2. Construct Validity: Convergent Validity and Discriminant Validity

Constructs	AV	HG	MD	MF	MP	UG	UI	WD	Cronbach alpha	Composite Reliability	AVE
Avatar (AV)	**0.859**								0.881	0.885	0.737
Hedonic Gratification (HG)	0.666	**0.889**							0.868	0.869	0.791
Metaverse Design (MD)	0.587	0.589	**0.845**						0.867	0.870	0.715
Metaverse Flow experience (MF)	0.749	0.642	0.621	**0.916**					0.936	0.938	0.840
Metaverse Purchase (MP)	0.608	0.514	0.698	0.426	**0.857**				0.909	0.911	0.735
Utilitarian Gratification (UG)	0.610	0.673	0.653	0.540	0.674	**0.879**			0.902	0.904	0.773
User Interactivity (UI)	0.614	0.646	0.415	0.463	0.605	0.548	**0.792**		0.859	0.867	0.634
Wearable Devices (WD)	0.623	0.662	0.550	0.508	0.475	0.628	0.490	**0.846**	0.866	0.881	0.716

4.2 Structural Model Assessments

Researchers used the PLS method and bootstrapping in Smart PLS 4.0 to analyse the structural measurement path coefficient (β), significant level (t-statistics), and coefficient of determination (R^2) for the nine submitted hypotheses (Hair et al. 2021). The estimated R^2 value for each endogenous construct, which represents the variance that may be explained by that construct, is calculated.

4.3 Hypotheses Testing

Table 3 shows the structural relationship between the constructs studied.

Table 3. Hypothesis testing

Hypothesis	Relationship	Beta(β)	T statistics	P values	Decision
H1a	MD -> MF	0.492	8.020	0.000	Supported
H1b	UI -> MF	0.273	4.588	0.001	Supported
H1c	WD -> MF	0.185	3.674	0.000	Supported
H1d	AV -> MF	0.375	5.968	0.000	Supported
H2b	MF-> HG	0.279	3.769	0.020	Supported
H2a	MF-> UG	0.036	0.589	0.577	Not Supported
H2c	MF-> MP	0.135	1.831	0.079	Not Supported
H3a	UG -> MP	0.118	1.611	0.131	Not Supported
H3b	HG -> MP	0.292	3.564	0.010	Supported

5 Findings and Discussion

The study investigated how Metaverse design characteristics, User Interactivity, Wearable devices, and Avatars constitute important dimensions for the Metaverse flow experience thereby influencing users' gratifications and purchases in Metaverse.

R-Square results demonstrate that Metaverse design characteristics, User Interactivity, Wearable devices, and Avatars explained 67.5% variance in metaverse flow experience. Flow experience explains 47.1% variance in Utilitarian gratification and 50.8% variance in Hedonic gratification. Utilitarian gratification, Hedonic gratifications, and Metaverse Flow experience explained 74% variance in Metaverse purchases. As reported in Table 3 the beta values of the path coefficients together with their statistical significance. Results demonstrate that metaverse design characteristics H1a: ($\beta = 0.492$, t-value 8.020), Users interactivity H1b: ($\beta = 0.273$, t-value 4.588), Wearable devices H1c: ($\beta = 0.185$, t-value 3.674) and Avatars H1d: ($\beta = 0.375$, t-value 5.968) favourably influenced metaverse flow experience. It was observed that Metaverse flow experience had a positive influence on hedonic gratifications as indicated by H2b: ($\beta = 0.279$, t-value 3.769) and as shown by H3b: ($\beta = 0.292$, t-value 3.564) Hedonic gratifications had a significant influence on Metaverse Purchase. It was interesting to note that as indicated by H2a: ($\beta = 0.056$, t-value 0.746) metaverse flow experience did not have a significant impact on Utilitarian gratifications. Further Utilitarian gratifications did not influence Metaverse purchase as shown by H3a: ($\beta = 0.118$, t-value 1.611). Also, it was observed that H2c (($\beta = 0.135$, t-value 1.831) metaverse flow experience did not have a direct influence on Metaverse purchase.

As we proposed, Metaverse Design and User interactivity constituted Metaverse media interactivity. Also, Wearable devices and Avatars constituted for augmentation in Metaverse. The findings show that customers can view metaverse flow experiences as authentic and immersive, which will gratify them and encourage them to make purchases on the metaverse platform. First, the outcome highlights how better Metaverse Design elements and User Interactivity are in creating flow experiences. Second, not only did Metaverse interactivity in general, induce flow, but also augmentation features, which are

unique Avatars and Wearable devices, contributed to flow experiences. Third, the flow state, derived from powerful and superior metaverse interactivity and augmentations, can lead to hedonic gratifications, but cannot provide utilitarian gratifications. Fourth, Metaverse service providers should consider enhancing media interactivity features and augmentation features, however, focusing on improving mental stimulation via enhanced 3D simulation techniques can influence utilitarian gratifications. Fifth, because they allow for the overlap of virtual and real-world elements, advanced Metaverse features may encourage both Metaverse purchases and utilitarian gratifications. This is done by enhancing the flow experience within the Metaverse, which can immerse users in a more realistic environment.

Metaverse flow allows consumers to build hedonic gratifications, triggering consumers' enjoyment, because consumers are immersed in the Metaverse environment Lastly, both utilitarian and hedonic gratifications built upon flow experiences can increase metaverse purchases (Javornik 2016). Metaverse platforms provide both usefulness and fun thereby impacting Consumers' purchase decisions.

5.1 Theoretical Implications

Our study's findings add to the body of existing literature by demonstrating how the theory of interactivity can be amalgamated with customers' gratifications theory in the context of metaverse technology. We offered empirical proof of the causes of the flow state experience and a gratification outcome during metaverse purchase, with an emphasis on the Metaverse media interactivity and augmentation. It specifically makes a novel contribution to the body of work on consumer behaviour concerning metaverse purchases. We highlight the importance of metaverse design characteristics, user interactivity, wearable devices, and Avatars when metaverse users choose the platform for their product-related searches.

5.2 Practical Implications

Almost anything that can be done in the real world can be done in a certain manner in the metaverse, allowing marketers and customers the chance to develop flow experiences and cutting-edge processes. The study emphasizes that consumers seek holistic product and brand experiences encompassing utilitarian and hedonic gratifications when the purchase is online. When developing content for marketing campaigns, brand managers should take significant metaverse flow factors like Metaverse interactivity and augmentation into account, according to our research model. In this way, we offer experts in the field some direction for their communications efforts in metaverse marketing. Marketers can gather insight into the metaverse flow factors that provide hedonic and utilitarian gratification thereby increasing purchases through the metaverse platform.

6 Conclusion

This paper examined the factors like Metaverse design, User interactivity, Wearable devices, and Avatars that lead consumers to the flow experience state. Further, the researchers found the users' gratifications as the consequence of consumers' flow experience in Metaverse that led to Metaverse purchases. Future studies can explore an ideal

combination of user characteristics and technology characteristics, to produce users' gratifications and flow states. In the metaverse, practically anything that can be done in real life can be done in one way or another, giving marketers and consumers the chance to create thrilling experiences and novel practices. To create positive customer experiences and flow states, researchers might investigate the metaverse marketing mix.

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A Conceptual Model for the Adoption of Digital Marketing by Micro, Small, and Medium Enterprises

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Abstract. The scope of digital marketing is spurred by the advent of cheaper internet and smartphone advancements. With social media platforms and other online media, digital marketing is becoming indispensable to companies' marketing arsenals. The reliance on digital marketing by firms was further boosted during Covid-19, and researchers are eager to explore the adoption of digital marketing and its usage by firms. This study attempts to uncover a conceptual model of digital marketing adoption by combining technology adoption models, such as the Unified Theory of Acceptance & Use of Technology 2 (UTAUT2), Perceived Characteristics of Innovation (PCI), and Task Technology Fit (TTF) theory. The model tries to extend the literature by adding two more constructs to the research realm of technology adoption – 'Product Channel Fit (PCF)' and 'Green Image (GI).' The proposed model can firmly explain the case of digital marketing adoption and present the opportunity to derive managerial implications.

Keywords: Digital Marketing · Micro Small and Medium Enterprises · PCF · GI · Technology Adoption

1 Introduction

Micro, small, and medium enterprises (MSMEs) are most countries' lifelines. MSMEs contribute to the country's overall growth in many ways, including employment generation (Deb et al., 2022), increased foreign exchange (Oni, 2021), and increasing GDP contributions (Joensuu-Salo et al., 2022; Low et al., 2022). For example, in India, MSMEs contribute 30% of the GDP and 49.5% of the country's exports, generating around 11.10 crore jobs. Recognizing the importance of MSMEs in the Indian economy, the government has taken many steps to foster and promote their development (Annual Report, Ministry of Micro, Small, and Medium Enterprises, 2021). Governments are trying to modernize MSMEs through initiatives such as funding (Babalola et al., 2015). Nevertheless, MSMEs face many issues, one of which is marketing. The majority of companies

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are struggling to market their products and services, especially with the advent of the Internet and digital media (Handayani et al., 2022; Joensuu-Salo et al., 2022). Marketing has been done solely through print, broadcast, direct mail, phone, and outdoor advertising, such as billboards (Nayati Utami et al., 2019). The introduction of the Internet provides more business opportunities for firms worldwide (Martins & Nielsen, 2020). Digital marketing provides MSMEs with several advantages over traditional marketing methods. Earlier researchers have suggested that adopting digital marketing improves firm performance (Mazzarol, 2015). However, digital marketing adoption by MSMEs is limited by various factors (Jokonya & Mugisha, 2019; Yaseen et al., 2019), and more clarity and explanation are needed regarding the factors affecting digital marketing adoption (Patil et al., 2022; Teixeira et al., 2018). Despite the abundance of models aimed at elucidating the factors influencing digital marketing adoption, a notable research gap exists in the absence of an integrated framework that consolidates and synthesizes the diverse insights offered by these individual models. Such an integrated model would not only provide a more nuanced understanding of digital marketing adoption but also offer practical utility for businesses seeking to navigate the complex landscape of digital marketing strategies. Currently, numerous environmental challenges are connected to marketing, and technical solutions can be used to address these difficulties (Zhang & Liu, 2022). Although digital marketing is considered eco-friendly (Lajevardi et al., 2021), studies are yet to be conducted on how environmental consciousness and the GI of digital marketing affect adoption. Additionally, it's essential to find out if PCF affects whether businesses choose to use digital marketing or not. Since every product is different, not all marketing methods work the same for each one. So, we need more research to understand how PCF specifically influences the decision to use digital marketing. Therefore, the authors attempt to extend adoption theories with new variables, PCF, and GI. The proposed conceptual framework attempts to answer the following research questions.

1. Does GI have a significant and direct effect on the digital marketing adoption of MSMEs along with other variables in the literature?
2. What is the role of PCF in the digital marketing adoption of MSMEs along with other variables in the literature?
3. What integrated conceptual framework can explain the drivers of the digital marketing adoption of MSMEs?

1.1 Digital Marketing

The term 'digital marketing' encompasses various measurable and interactive marketing techniques to attract, convert, and retain potential customers through digital technologies (Kannan & Li, 2017). By leveraging technology, digital marketing caters to customer needs and promotes products or services through various digital channels (Dave Chaffey et al., 2013). Commonly referred to as internet marketing, online marketing, e-marketing, and web marketing, digital marketing includes several tactics such as social media marketing, content marketing, email marketing, search engine optimization, pay-per-click advertising, SMS marketing, and mobile marketing (WebFx, 2020).

1.2 Digital Marketing and MSMEs

The existence of MSMEs is crucial for all nations. Hence, the government has constantly implemented new regulations to protect these businesses (Zulu-Chisanga et al., 2021). However, MSMEs face unique difficulties and limitations; consequently, businesses frequently incur significant losses and occasionally cease operations (Okamuro 2020). Even with modest marketing resources, MSME enterprises can employ digital marketing services to obtain notable results. (Tiago & Veríssimo, 2014). Gaining clients and consumers is essential for any business, especially for MSMEs. Studies have shown that many MSMEs need help with marketing issues and must satisfy their potential clientele (Eggers, 2020). Through digital marketing initiatives, MSMEs enthusiastically connect with their clients and staff (Taiminen & Karjaluoto, 2015). Digital marketing offers MSMEs many advantages over traditional marketing, such as low marketing costs (Cadavid & Valencia-Arias, 2022), awareness (Noerlina & Mursitama, 2022), return on investment (T. Singh et al., 2021), easy measurability (Mitova et al., 2021), precise targeting (Bizhanova et al., 2019), improved segmentation (Eid et al., 2006), and greater engagement (Salo et al., 2013). Many researchers tried to explore the factors determining digital marketing adoption by micro, small, and medium enterprises using different technology adoption models (Eze Id et al., 2021; Nur et al., 2022).

2 Literature Review and Model Development

The research field of digital marketing adoption lacks a unified framework that integrates various adoption models. Existing models, while valuable, focus on specific aspects, leaving a gap in our understanding of how these factors interact comprehensively. An integrated model is needed to provide a holistic view, benefiting both research and practical application in the complex realm of digital marketing strategies. The three popular technology adoption models are UTAUT2, PCI, and TTF. UTAUT2 helps us understand what employees think about digital marketing tools and how their colleagues influence their views. PCI helps us look at the characteristics of these new technologies and how well they fit with what the businesses need. TTF focuses on making sure the technology matches the tasks the businesses want to do. By bringing these theories together, we can look at all the different factors that affect how small businesses adopt digital marketing.

2.1 Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2)

UTAUT2 combines constructs from different adoption models, including TAM and TRA (Venkatesh et al., 2003). Researchers have used UTAUT 2 to study digital marketing adoption (Bellaaj, 2021; Salimon et al., 2021).

UTAUT 2 Constructs

Performance Expectancy.

When customers expect increased efficiency and benefits, they are more inclined to adopt new technology (Dwivedi et al., 2019). It's a key factor in adopting digital medias

(Chopdar & Sivakumar, 2019; Eneizan et al., 2019). Hence, the first hypothesis is as follows.

H1: Performance expectancy influences the intention to adopt digital marketing by MSMEs.

Effort Expectancy.

Effort expectancy also significantly influences intention to adopt different digital marketing channels (Eneizan et al., 2019; Indrawati & Primasari, 2016; Turan & Kara, 2018). Hence, we propose the following hypotheses:

H2: Effort expectancy influences the intention to adopt digital marketing by MSMEs.

Social Influence.

This concept has a positive effect on adopting different digital platforms (Chimborazo et al., 2021; Chopdar & Sivakumar, 2019; Turan & Kara, 2018). Additionally, social pressure from managers, colleagues, consultants, and agencies also plays a role (Indrawati & Primasari, 2016). Hence, we postulated the following:

H3: Social influence impacts the intention to adopt digital marketing.

Facilitating Conditions.

This variable is linked to the adoption of mobile and social marketing channels (Chimborazo et al., 2021; Shoheib & Abu-Shanab, 2022). MSMEs are more likely to adopt digital marketing when they have a supportive environment, including employee training and minimal resistance to change. Hence, we hypothesize as follows:

H4: Facilitating conditions of digital marketing influences the intention to adopt digital marketing by MSMEs.

Hedonic Motivation.

Consumers are increasingly attracted to innovative and appealing social media commercials, and engaging in digital marketing advertising can be more enjoyable than traditional media (Dwivedi et al., 2019;). Hedonic motivation drives digital marketing adoption (Chimborazo et al., 2021; Shoheib & Abu-Shanab, 2022) making MSME owners more inclined to embrace it when they find it enjoyable. Hence, we propose the following hypotheses:

H5: Hedonic motivation of doing digital marketing influences the intention to adopt digital marketing by MSMEs.

Price Value.

Price value impacts the adoption of different digital and mobile marketing platforms (Shoheib & Abu-Shanab, 2022). Digital marketing's cost-effectiveness and precise audience targeting make it especially valuable. Therefore, we hypothesize as follows:

H6: The price value of digital marketing influences the intention to adopt digital marketing by MSMEs.

Habit.

Habit directly impacts technology adoption and can weaken the link between intention and actual adoption (Limayem et al., 2007). Habit is pivotal in m-commerce (Chopdar & Sivakumar, 2019). Hence, we postulate the following hypothesis:

H7: The habit of using digital marketing influences the intention to adopt digital marketing by MSMEs.

Intention to Adopt and Adoption.

Most studies concentrate on factors affecting the intention to adopt digital marketing and not the actual adoption (Giampietri & Trestini, 2020). Investigating how intention translates to actual adoption is essential. Therefore, we propose the following:

H8: Intention to adopt digital marketing influences the actual adoption of MSMEs.

2.2 Perceived Characteristics of Innovation (PCI)

PCI theory, devised by Rogers, encompasses subjective qualities and attributes individuals associate with a new idea, product, or technology, which influence their acceptance and adoption of it.

PCI Constructs

Relative Advantage.

When digital marketing offers more benefits than current strategies, adoption likelihood increases (Shaltoni et al., 2018). Relative advantage has a direct impact on intention to adopt different digital channels (Hossain et al., 2022). Therefore, we propose the following proposition:

H9: Relative advantage influences the intention to adopt digital marketing by MSMEs.

Compatibility.

The adoption rate is higher when consumers perceive the innovation as compatible with their views and experiences. Compatibility is crucial for digital channels (Walker et al., 2016) adoption. MSMEs tend to embrace digital medias when they align with existing tech. Therefore, we hypothesize as follows:

H10: Compatibility influences the intention to adopt digital marketing by MSMEs.

Complexity/Ease of Use.

The simpler an innovation, the faster it's adopted (Rogers, 1995). Ease of use influences SMEs' choices, impacting digital marketing adoption (Chung, 2019). If digital marketing seems easy to MSMEs, they're more likely to embrace it. Consistent with previous studies, we postulated the following:

H11: Ease of use influences the intention to adopt digital marketing by MSMEs.

Trialability.

More trialability leads to higher adoption rates and reduces uncertainty. It's been seen in mobile commerce and website personalization (Chung, 2019). Hence, we hypothesize as follows:

H12: Trialability influences the intention to adopt digital marketing by MSMEs.

Visibility/Observability.

Visibility matters for adoption (T. H. Greer & Murtaza, 2003). As digital marketing becomes more visible through social media and mobile marketing, its adoption rises. Therefore, we hypothesize as follows:

H13: Visibility influences the intention to adopt digital marketing by MSMEs.

Result Demonstrability.

Tangible results drive adoption (T. H. Greer & Murtaza, 2003). Through digital marketing, MSMEs favor digital marketing when they witness tangible results, like increased sales and website traffic. Therefore, we propose the following:

H14: Results demonstrability influences the intention to adopt digital marketing by MSMEs.

2.3 Task Technology Fit (TTF) Theory

Goodhue and Thompson's (1995) TTF theory assess tech adoption by matching it with users' tasks. When tech fits well, it's used; otherwise, it's not. TTF impacts mobile banking apps and B2B tech adoption. It underscores aligning tasks with tech.

TTF and Digital Marketing Adoption.

TTF positively affects social media (Justino et al., 2022) adoption by aligning tasks with technology, enhancing digital marketing's effectiveness. Hence, this study proposes the following:

H15: TTF influences intention to adopt digital marketing.

2.4 Product Channel Fit (PCF)

Marketing channels have different capabilities and products have unique characteristics that require a fit between the two (Bang et al., 2013; Han et al., 2021). PCF refers to the alignment between marketing channels and product characteristics (Bang et al., 2013). If a product is suitable for digital marketing, there is a higher likelihood of digital marketing adoption. Understanding how the alignment between product characteristics and marketing channels affects adoption is crucial for businesses, particularly micro, small, and medium enterprises (MSMEs), seeking to optimize their digital marketing strategies. This gap hinders a holistic understanding of the adoption process and limits the practical guidance available to businesses aiming to navigate the complex landscape of digital marketing effectively. Addressing this research gap is essential to provide businesses with a more nuanced perspective on digital marketing adoption, ultimately facilitating informed decision-making and strategy development. Therefore, we hypothesize as follows:

H16: PCF influences intention to adopt digital marketing.

2.5 Green Image (GI)

Green marketing strategies such as digital marketing can effectively raise awareness and develop a positive GI (Lajevardi et al., 2021). Consumers increasingly prioritize environmental concerns, making a GI an important factor in purchase intention (Kamalanon et al., 2022; Le et al., 2022). Previous research has demonstrated the positive effect of GI on technology adoption, such as drones (Mathew et al., 2021). Recognizing the role of the GI in digital marketing adoption is vital, as organizations increasingly prioritize sustainability in their marketing strategies. This research gap limits our holistic understanding of the factors shaping digital marketing adoption decisions, especially in the context of evolving environmental concerns. Hence, we hypothesize as follows:

H17: The GI of digital marketing influences intention to adopt digital marketing.

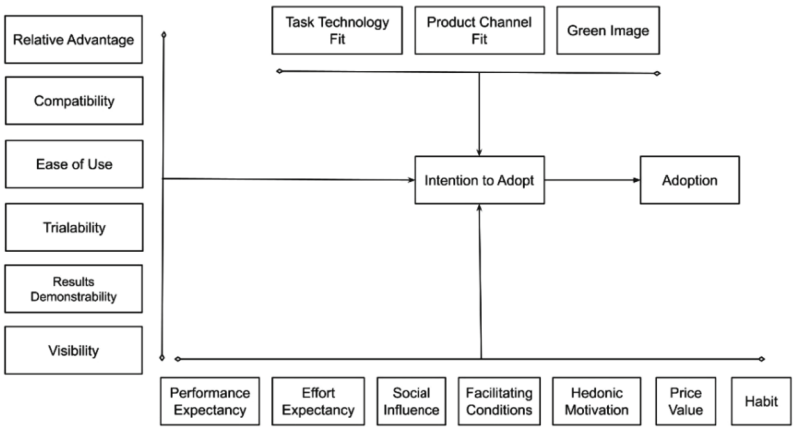

Fig. 1. The conceptual model for predicting digital marketing adoption by MSMEs (Source: Authors)

3 Theoretical Contributions

This study introduces a conceptual model (Fig. 1) that significantly advances the current theoretical landscape in the study of digital marketing adoption by MSMEs. Firstly, the integration of three established theories—UTAUT2, PCI, and TTF—creates a comprehensive framework that addresses the multi-faceted nature of technology adoption. This amalgamation allows us to delve into individual perceptions, social influences, innovation characteristics, and technology-task alignment, offering a holistic view of the adoption process. By combining these theories, we bridge gaps in existing models that often focus on isolated aspects of adoption, enabling a more nuanced understanding of the complex interplay between cognitive, contextual, and practical factors that influence MSMEs' digital marketing adoption decisions. The inclusion of two new variables, PCF and GI, significantly improves the research model's depth and relevance to the study of digital marketing adoption by MSMEs. PCF's introduction acknowledges that not all marketing channels are universally suitable for all products in the digital marketing landscape. This recognition of the nuanced relationship between product characteristics and channel choices addresses a notable gap in the literature. It offers a more refined perspective on how MSMEs make decisions regarding digital marketing adoption, reflecting the real-world scenario where product-specific factors impact channel selection. On the other hand, GI is highly pertinent in today's sustainability-conscious business environment. It acknowledges the growing importance of eco-friendly practices and their influence on consumer preferences. By exploring whether MSMEs adopt digital marketing to convey their commitment to environmental sustainability, this variable contributes to a more holistic understanding of the factors driving digital marketing adoption. In essence, both variables extend the research model's scope and applicability, enriching its capacity to capture the complexities of digital marketing adoption among MSMEs.

4 Directions for Future Research

Empirical studies based on the proposed research model using validated scales from previous research are suggested. Future research could investigate how other variables mediate and moderate the factors affecting digital marketing adoption, such as firm size, industry type, expertise, age, and gender. More research is needed to understand how the GI of technology impacts its adoption in different scenarios. Also, future studies can identify digital marketing technologies that are most suitable for different types of products.

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Unified Metaverse Architecture Powered by Blockchain Decentralized Autonomous Organizations (DAO)

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Abstract. Metaverse platforms or ecosystems can be considered virtual or extreme reality spaces where end-users live, communicate, collaborate, entertain, work and game with other personas or avatars in computer-simulated environments. Metaverse environments envisage a cybernetics future where man, machine and systems work together in the virtual world to replace humans. Metaverse platform's vision is to integrate communities, products, service offerings, creators, commerce, entertainment, workspace etc. Metaverse works on the self-service marketplace requiring many formats of digital payments based on the transaction type. Metaverse virtual operations happen worldwide beyond the firewalls and state boundaries using the internet. Legislation and jurisdiction enforcement are challenging as they go beyond countries and are primarily untraceable sources. Hence, there is a need to study the metaverse components of resources required, communication network essentials, orchestration/automation possibilities, virtual organisation prerequisites, interface-spatial considerations and well-thought experience ecosystems. This paper proposes the architecture of virtual metaverse space using the blockchain-led decentralised autonomous organisation to create immutable, transparent, fair, inclusive and socially immersive platforms using smart contracts and distributed apps (DApps). The proposed unified metaverse architecture powered by the decentralised autonomous organisation (DAO) is the gateway design for metaverse infrastructure (computing and networking resources) to the orchestrated virtual-meta environment (interface, spatial and experience).

Keywords: Metaverse · decentralized autonomous organization (DAO) · metaverse layered architecture · blockchain · smart contracts

1 Introduction

Decentralized autonomous organization (DAO) is not just the technology solution or the platform; the modus operandi of DAO operation influences society, systems structure and communities as a whole. The potential of decentralized systems impacts the design of the governance systems autonomously [9, 10]. DAO is not affiliated with any agency, state or

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system; it is a community of members who make decisions using consensus algorithms in many industries-based use cases [11]. DAO types are continuously changing as per the Web 3.0 to Web 5.0 transformations use cases ranging from metaverse, social, utility, grants, investments, corporate governance etc. The DAO platforms rendering different offerings, marketplaces, skills and integrations to provision skills, tools and technologies in a service model are classified as service DAOs [3]. The metaverse platforms offer multiple agencies, avatars and individuals to provide services useful for decentralized development, managing, running and operating models [13]. DAO brings a transparent and trustful mechanism to deploy the rewards and incentive systems powered by smart contracts [5]. The real-time payment systems, consensus mechanisms and tokenization support the automated rule-based incentivization of member participants contributing to the P2P network [7, 8]. The API integration, metaverse ecosystems and discords provide the flexibility to providers and developers to interact and position arbitrage services in a tokenized economy. It will help to optimize the transaction cost within the payment and incentivization systems. The reward system to appreciate the efforts of decentralized member contributors increases the system's reputation [11].

Moving from crypto economics, DAO is getting attention from government, agencies and mainstream businesses as it promotes digital communities. Initially, only the non-profit use cases from NGOs and communities were visible in the marketplaces, but now full-fledged business models based on industry use cases are propelled to grow the business [4]. The business is not limited to a small scale but can even run the nation's economy per the promises of DAO potentials [2]. The metaverse, gaming, banking, supply chain, media & entertainment, social and healthcare, etc., realize the capacities of DAO power [11]. DAO is becoming the economic forum-based potential marketplace to offer decentralized services, community projects, grants pooling platforms and digital governance instruments (Pilkington, 2021). The knowledge economy is pivotal in the growth of DAO business and economic transformations with a compelling offering from decentralized universities, skills rendering platforms, certification channels and outsourced business models [14, 16]. Novel platforms from the metaverse, green revolution, supply chains, and distribution are changing the economic models across borders, which were difficult to think about some years ago [11]. DAO solutions span beyond financial solutions because it pertains to voting-based consensus building, powering SSIDs in the metaverse, decentralized storage systems, governance systems for states, NFTs to preserve the proof of ownership etc. [12].

Metaverse as an idea/experimentation looks ambitious, but technological advancements make the virtual world's imaginations real [6]. Today metaverse systems face multiple challenges in the pseudo-virtual world. Personal identity and reputation are a big concern in the metaverse world, where a person can mimic other's identities if not appropriately authenticated [1]. This can jeopardize the reputation of the individual. Metaverse heavily depends on the individual's data and information stored on computing devices used on an online virtual platform. Metaverse requires more sophisticated invulnerable data and privacy protection methods to safeguard the users' interests [15]. Therefore, it motivated us to propose a unified metaverse architecture approach covering the layers of

resources required, communication network essentials, orchestration/automation possibilities, virtual organization essentials, interface-spatial considerations and well-thought experience ecosystems. Therefore, the research responds to following research question.

RQ: How to propose a layered unified metaverse architecture powered by blockchain decentralized autonomous organisations with the potential of algorithmic trust led decentralised meta ecosystems?

2 Unified Metaverse Layered Architecture

The proposed architecture embeds the time and space work like a mirage in the virtual world, as users are unaware of the bodies and the timestamp with associated performed actions. This immersive action in infinite space becomes the new potential to keep track of time, space and users at a time. The proposed architecture maintains an immutable ledger while storing and keeping track of virtual space activities and transactions. The decentralized unified metaverse architecture maintains the identity, reputation, data protection, financial transactions, law enforcement, IP rights and time-space stamps of virtual users using smart contracts and DApps. The processes, task logs, and events are timestamped and hashed as an immutable ledger that external parties or federal agencies can audit if required. Trust, reliance, records immutability and transparency are the key criteria in the virtual world to convince the users. Taking the potential to the next perimeter is the management of assets in the virtual world in its ownership. Intellectual properties (IP) rights for virtual creation provide the options for the true tokenization efforts to authenticate the virtual assets possessors. Figure 1 represents the proposed Unified metaverse architecture powered by the decentralized autonomous organization (DAO). It comprises six layers, namely.

Metaverse Resource Layer
This layer consists of hardware/cloud infrastructure like sensors/actuators, communication hardware, computing hardware for an edge, serverless or basic infrastructure and specific purpose-built infrastructure using GPUs for metaverse and blockchain platforms powered by Ethereum, Hyperledger or any other foundational layer.

Metaverse Communication Layer
This layer comprises the network backbone of the metaverse platform for various communication mediums for edge networks, service mesh, blockchain node network and metaverse software-defined networks (SDNs) and network function virtualization required for the seamless virtual integration among users with immersive characteristics.

Metaverse Orchestration Layer
Metaverse platforms require stabilization and regulation per business, social, and moral ethics requirements. The orchestration layer powers ethical toolkits and artificial moral agents (AMAs) to manage the metaverse workflows with pre-built topology designs.

It also consists of the autonomic characteristics of self-healing, self-configuration and self-immune the ecosystems due to malicious activities.

Decentralized Autonomous Organization Layer

This layer comprises the DAO infrastructure (decentralized and authenticated) to be the base installation of DAO product suites. It can comprise a metaverse marketplace for virtual identities that can provide the services like brokerage, composition, intermediation and arbitrage of the metaverse services to create new profiles, personas and avatars. The toolset brings DAO-based governance and audit functionalities within the node network while managing identity, reputation, data protection, financial transactions, law enforcement and IP rights.

The DAO layer manages the time and space stamps with the log details for the virtual users. It consists of the modules like intelligent contracts to maintain the relationship between providers, virtual users and avatars. DApps are also required or can be rendered from community-based DAO marketplaces to ease the transactions. The consensus module helps get the digitally signed and authenticated approvals to validate the transactions. The tokenization module incentivizes the specific node performing the transaction initiated on behalf of the virtual space users and metaverse ecosystem players.

Fig. 1. Unified metaverse architecture powered by decentralized autonomous organization (DAO)

Metaverse Interface and Spatial Layer

This layer helps to integrate the gadgets and systems to sense various characteristics like haptic, gestures, voice, objectron, KNIFT (Keypoint Neural Invariant Feature Transform), object detection/tracking with neural capabilities using HMDs, 3D/4D engines, live ML and robotics systems.

Metaverse Experience Layer

This layer provides the abstraction to the complex underlying metaverse architecture by presenting a delightful metaverse experience to the end-user by simulating the real systems of gaming, social, e-commerce, entertainment and education ecosystem surrogates.

3 Research Implications

The research proposes implementing the DAO characteristics-based unified metaverse architecture for (extreme reality) XR, virtual reality (VR) and augmented reality (AR) in a decentralized model. The proposed architecture presents a decentralized system leveraged by a metaverse network-based orchestration system model to deliver efficient, optimal, self-managed, cost-effective virtual unified spaces. It also provides an interface, spatial and experience platform for complex decentralized virtual spaces equipped with ethics management, artificial moral agents (AMAs), live Machine learnings (MLs) and autonomics powered by smart contracts and DApps. Logs are recorded once virtual space activities and transactions are actioned on the unified DAO-led metaverse network. To ensure data integrity, they cannot be tampered with by intermediaries, nodes, or even real users (mimicking avatars or personas). Pseudo-virtual space activities and transaction information will be available to every node; hence data (transaction details) will be available in cases of system failure with the details of time and space stamps. Smart contracts and DApps-based transactions between virtual users will provide trust and transparency while improving efficiency significantly.

4 Managerial Implications

The proposed architecture can be developed by managers as a universal platform by metaverse virtual space providers to maintain the virtual users/ avatars/ persona in a decentralized system. Since this method can reduce the complexity and maintenance efforts and bring down the total cost of ownership (TCO) for XR/VR/AR metaverse platforms, any organization can deliver this as a valuable offering. Organizations/agencies can use the proposed architecture to adhere to cross-border legislation and jurisdiction enforcement in the virtual metaverse spaces. Organizations can add this solution (architecture) as a new XR/VR/AR metaverse offering and pitch the product to the cloud service provider (CSP) catalogue. The proposition provides the standard Open Architecture to XR/VR/AR metaverse platforms integration or CSP ecosystem, ensuring interoperability.

5 Conclusions

Metaverse architectures are data-intensive design considerations maintaining open standards and interoperable activities over the network. Metaverse technical communities/practitioners are willing for a unified method to represent technology components' infrastructure, interface, spatial and experience layers. The paper presents first of its kind metaverse unified layered architecture powered by a decentralized autonomous organization to orchestrate the infrastructure and interface/spatial layers of meta-world solutions. The proposed architecture integrates the most sought architectural response to the issues of meta-ethics powered by ethical toolkits and artificial moral agents (AMAs) to manage the metaverse workflows. The governance of meta-platforms requires the autonomic characteristics of self-healing, self-configuration and self-immune ecosystems. The DAO toolsets provide the options of brokerage, composition, intermediation and arbitrage of

the metaverse services to create new profiles, personas and avatars. It helps to lay down the governance and audit functionalities to manage identity, reputation, data protection, financial transactions, law enforcement and IP rights. The meta devices are the gateway to integrating the feel, touch and sense characteristics like haptic, gestures, voice, objection, KNIFT, and object detection/tracking with neural capabilities covered under the interface and space layer. Metaverse unified architecture is relatively new; hence more research is required with academic lenses to understand the meta-world architecture design. Adopting the proposed metaverse architecture requires qualitative and quantitative experimentation using interviews, narratives and statistical testing. Metaverse architecture is being curated majorly in open-source world standardization, and intellectual capital/property management is daunting and requires specific study. Metaverse is emerging with many use cases in various industries; hence, industry analysis requires architecture validation. Objectively, the architecture provides the abstraction to the user for complex metaverse components and renders a delightful metaverse experience to the absolute gaming, social, e-commerce, entertainment and education systems.

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The Role of Micro Influencers in the Consumer Decision-Making on Budget Hotels in the Indian Context

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Abstract. The hospitality industry is a dynamic one that has evolved in its services and operations from being merely an accommodation provider to now being an experience provider. In more recent times, hotels have been engaging more frequently with micro influencers benefitting from their reach among the desired target audience through their followers as well as gaining marketing advantage at a large scale but at a relatively low cost and involvement rate. Budget hotels, especially, like OYO, Fab, and Key hotels as well as the luxury brand budget accommodation arms like Ginger, Fortune, Fairfield and more have been widely hopping onto this trend.

With the goal of understanding the impact that micro influencers have on consumer decision making on budget hotels in the Indian context, this study set out to understand the role that micro influencers play in the consumer decision making on budget hotels, gain insights on the importance and usefulness of user-generated content, find out if social media has an impact on consumer decision making, and understand the reasons behind the conversion of consumers' purchase intentions to actual purchase actions. Involving two hundred respondents pan India, through the random and snowball sampling techniques, eight factors were considered, namely: Influencer Marketing, Role of Influencers, User Generated Content, SMIs, Purchase Intention, Economic Value, Aesthetic Value, Perceived Value. The results to the survey form circulated among the respondents were analyzed and interpreted with the help of Factor and Regression Analyses conducted on the SPSS software by IBM. Ultimately, five hypotheses relating to customer decision making while choosing budget hotels and the role of micro influencers in it were focused on in the study and proven to be true based on the findings.

Keywords: Micro-influencers · hospitality · consumer decision-making

1 Introduction

The digital revolution has affected all aspects of consumers' lives. Travel and tourism have long been a global phenomenon for customers, especially from developed countries. Recent studies suggest that consumers have a poor recollection of advertisements

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and worse do not recall the brand message (Talaverna 2015). Consumers use tools such as ad blockers to skip online advertisements (Dogtiev 2016). In the present era, consumers use social networks and the Internet to share their experiences and opinions, in order to find out information about products or services, and to make purchases online (Katawetawaraks and Wang 2011) Social networks have become an integral part of people's day-to-day lives. Social networks constitute an ensemble of applications that enable people to share their content, opinions, and experiences, and also allow access to entertainment and news (Faria and Elliot 2012; Ngai et al. 2015; Khan et al. 2017). Internet has enabled the emergence of people who share their experiences and opinions on certain products and services, known as influencers, as they are able to influence consumers in their decision-making processes (Roelens et al. 2016) Shared multimedia content, such as photos and videos, helps the tourists to imagine the hotel or destination (Terttunen 2017; Xu and Pratt 2018) Regarding micro-influencers, it is also important to mention blogs, as most hotel and travel micro-influencers usually post to a blog to support their shares on social networks (Neiva 2018).

In the recent times, the increasing demand for influencer marketing (mega, macro, micro or nano) has attracted the attention of hospitality brands around the world, reaping the benefits of eWOM (Electronic Word of Mouth), especially through social media platforms like Instagram, YouTube and TikTok, on which, these individuals influence purchase decisions of their followers since they recommend products, services and brands of which they collaborate with. This serves to be advantageous for brands since they get positioned among the potential customers well through individuals they relate to. Trammell and Keshelashvili (2005) are of opinion that influencers are often described as holding strong opinions and being reliable and frequently sought after by their peers for advice, whether online or offline (Freberg et al. 2011). The Research gaps is operating environments and constantly working on mitigating competition, the hospitality industry, as a whole, has been noticed to have been largely engaging with micro influencers. However, not much studies have been done on the role of micro influencers impacting the selection of budget hotels, the mode of digital media platforms used by the influencers to create an impact have also not been studied by the previous authors. For quicker results in its budget specific categories in Hospitality sector, micro influencers can create a significant impact as follows:

- can be a powerful tool for hotels to reach out to and engage with potential guests.
- have a highly engaged following that is interested in travel, food, and experiences.
- provide hotels with a good enough follower base to reach out to potential guests.

Micro influencer marketing serves to be an interesting and subtle strategy that puts the hotel brands forth in the consumer markets through consumers being given ample opportunities to try them out upfront, is a highly beneficial tool, especially for budget hotels since they can reap benefits in shorter durations and to greater extents with lower expenditure rates. Micro-influencers are not driven by monetary reward, unlike larger scale influencers, which makes them more reliable, truth and accessible in the eyes of their audience (Gretzel 2018; Lin et al. 2018; Neves and Liljeblad 2017). The online purchase process implies not only using technology, but also having confidence in the product one is buying and the seller one buys from (Katawetawaraks and Wang 2011).

This research study focuses on the role of micro influencers who play a significant role in the selection of budget hotels. As micro influencers charge very less and have followers in a specific region, their knowledge is tremendous. Social media influencers' posts have two purposes: to increase their fans' purchase intention and enhance product knowledge or product attractiveness. Brands have been increasingly using micro-celebrities or so-called 'social media influencers that is, fitness gurus, food bloggers, beauty bloggers, fashionistas and others as the face of their advertisements (Khamis et al. 2017; Pedroni 2016) Influencers share endorsed opinions about products on social media platforms, such as Instagram, which assist in spreading viral conversations about brands online (De Veirman et al. 2017). As a result, they engage in native advertising or sponsored posts (Campbell and Grimm 2019), allowing payment for what they share on social media platforms. Researchers are increasingly recognizing the importance of social media influencers and their impact on marketing activities, as evidenced by numerous online articles (see e.g. Hill 2019; Petrofes 2018). This represents a considerable gap given social media influencers are being consistently leveraged and paid. The brands and organizations invest significant money in native advertising to promote their products. For instane, reports suggest that travel influencers can be paid up to $31,000 per post (Wallace 2018). Social media influencers' posts have two purposes: to increase their fans' purchase intention and enhance product knowledge or product attractiveness. Social media influencers design posts with testimonials or facts about product features, thus attempting to enhance information value and product knowledge (Luo and Yan 2019).

2 Literature Review

- Jiwoon Park et al. (2021) investigate the efficacy of mega and macro social media influencers in promoting products. According to the study, macro-influencers are more efficient for brands with less endorser congruence whereas mega-influencers can increase brand equity and credibility for those with established congruence. The study also showed that by including variables more suited to social media ecosystems, consumer interaction with endorsers and customer brand engagement, mainstream models for evaluating influencer behavior as endorsers might be improved.
- Samantha Kay et al. (2019) describe how social media influencers affect consumer outcomes, specifically how disclosure affects consumers' intentions to make a purchase. The study conceptualizes and distinguishes between macro and micro social media influencers and investigates their effectiveness in promoting products. The results imply that native advertising sponsorship disclosure is essential in influencing consumer opinions of items. The study has ramifications for businesses and social media influencers on a theoretical, practical, and policy level. It is reported on the validity and reliability of the study's metrics.
- An Exploratory Study of Millennial Consumer Behavior Antecedents Using Influencer Marketing, Kumar, Sunny; Kuldeep (2023). In-depth respondent interviews. Today's consumers are knowledgeable and alert. Influencers play a key role in customer decision making. Influencer marketing is a fairly new concept and so much historical information is not available on it for reference.

- Relationship Between Influencer Marketing and Purchase Intention: Focusing on Vietnamese Gen Z Consumers, Nguyen, Cuong et al. (2022). Questionnaire. Gen Z constitutes individuals high on ego and self-esteem leading them towards collecting information from varied sources about various trends and product offerings, influencing their purchase decisions. As a result of this, influencer marketing is beneficial since they receive information from one source that is more relatable and like them and so more believable.
- The Importance of Social Influencer-Generated Contents for User Cognition and Emotional Attachment: An Information Relevance Perspective, Zhang et al. (2022). Questionnaire, Snowball sampling. Influencers play a huge role in consumer decision making, especially when there is an emotional bond created between the two entities, making them want to follow them and replicate their actions. An in-depth analysis of its facets may have deepened the understanding.
- A Sequential Mediation Model of Storytelling Content and Audience Engagement via Relatability and Trust, Atiq, Madiha et al. (2022). Questionnaire. Storytelling and creation of a relationship with the audience, makes consumers want to engage more, then also trusting the influencers while making purchase decisions because of the connection so created. An in-depth exploration may have clearer results, validating the current ones.
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- Psychological Ownership in Social Media Influencer Marketing, Pick, Mandy (2021). Questionnaire, Stimuli based questioning. Influencers have a positive effect on brands and their sales, making them increasingly Popular. It is limited in terms of platforms, cultures and geographies, as well as consumers' personality traits considered.
- The Role of Micro-Influencers in the Consumer Decision-Making Process in the Hospitality Field, Rita Peres, Mariana Silva (2020). Qualitative - micro influencer and celebrity interviews, Quantitative - consumer surveys. Micro-influencers play a significant role in consumer purchase decision making in the hospitality area and the IACM model highlights the credibility of eWOM information through its positive effects on the usefulness of the information. The lack of studies & scientific articles addressing the role of micro influencers in the hotel industry and in consumer decision making.

- The Impact of Online Reviews on Inbound Travellers' Decision Making, Jayathilaka Ruwan; Dharmasena Thanuja et al. (2020). Exploratory, Qualitative, Quantitative research. Service quality plays an important role from the perspective of the customers and they dislike the perceived quality gaps. The study is limited to three five-star boutique hotels in Colombo with limited inbound travelers and online reviews highlighting the need for a larger cohort to be considered for a better understanding and more accurate research findings.
- An extended COPRAS Model for Multi-criteria Decision-making Problems and its Application in Web-based Hotel Evaluation and Selection, Jagannath, Roy et al. (2019). Detailed analysis and understanding of the WIRN and COPRAS models. The study lists three factors that seem to be most important to the customers in decision making along with highlighting those that rank at the bottom, rough the model, hotels and their authorities can better focus on their weaker areas so as to improve their service qualities.
- The Influencing Role of Social Media in the Consumer's Hotel Decision-making Process, Gupta Vikas (2019). Social media affects consumers' searches, decisions and bookings, aiding them in collecting information, assessing alternatives and decision making. Circumstantial influence of social media has an impact on hotel selection, based on content source, trust levels and content accuracy.
- Instafamous and Social Media Influencer Marketing, S Venus Jin; Aziz Muqaddam; Ryu, Ehri (2019). Focus group comparison, Random sampling. Customers engaging with Instagram celebrities' posts portray a higher tendency to trust the brand with a positive attitude. It is limited to one brand and category and one platform. It does not consider the nationality and background of the respondents.

3 Objectives

- To Identify the role of micro-influencers in influencing consumer decision-making for budget hotels.
- To Investigate the factors that influence consumers to build trust in micro-influencers for decision-making.
- To Identify the role of micro-influencers in capturing the market with their post in terms of Economic Values, aesthetic value, and Perceived Value.

4 Hypothesis

H1: There is a significant impact of micro-influencers in influencing consumer decision-making for budget hotels.
H0: There is no significant impact of micro-influencers in influencing consumer decision-making for budget hotels.
H2: The factors influencing consumer decision has a significant effect on building trust in micro-influencers.
H0: The factors influencing consumer decision has no significant effect on building trust in micro-influencers.
H3: There is a significant impact of micro-influencers to capture the market with their posts in terms of Economic Values.

H0: There is no significant impact of micro-influencers to capture the market with their posts in terms of Economic Values.
H4: There is a significant impact of micro-influencers to capture the market with their post in terms of Aesthetic Value.
H0: There is no significant impact of micro-influencers to capture the market with their post in terms of Aesthetic Value.
H5: There is a significant impact of micro-influencers to capture the market with their posts in terms of Perceived Value.
H0: There is no significant impact of micro-influencers to capture the market with their posts in terms of Perceived Value.

5 Research Design

5.1 Qualitative Analysis

The Research Study undertaken for this study emphasized Mixed Method Research and as a part of this two Focused Group Discussions were carried out by the Researchers in the city of Mumbai and Pune. Each Focused Group Discussion had 20 respondents primarily comprising the millennials who are influenced by social media and Influencer Marketing. The respondents were chosen carefully from different walks of Life in both these cities. The Researchers made a set of 15 Questions to execute this study. The primary focus of the Qualitative Research was to gauge the reasons behind the consumers' purchase intentions to the actual purchase actions and the role of the Influencers in this consumer decision making process. The following are some of the important factors that were studied: The Role of Micro influencers who play an important role in the selection of budget hotels. What are the reasons for the belief of these influencers by the consumers while booking a budget hotel?. How the user generated content impacts the overall selection parameters of the consumers?. The consumer decision making process resulting in purchase action while booking a budget hotel?. Any other reasons other than the role of influencers in decision making?. The Focused Group Discussion threw some important findings:

- The Millennials were highly influenced by Micro influencers in purchase decision making while selecting the budget hotels.
- The knowledge, trust and admiration for the influencers was greater than the role of celebrities in the decision-making process for budget hotel bookings for brands like OYO, Keys, Fortune, Ginger Hotels respectively.
- The respondents trusted the influencers who were regular travelers "walk the talk" was the primary reason for the trust.
- As the micro influencers already stayed in these budget hotels, their recommendations were of immense positive feedback for the consumers'.

Thus, the budget hotels should rely more on the micro influencers as they can connect with their target market the best.

5.2 Quantitative Analysis

In this research we used mixed method both qualitative as well as quantitative. In order to carry out the interpretation and analysis of the data obtained from the questionnaire floated through random and snowball sampling, IBM SPSS was utilized as the statistical tool. Enabling the analysis, factors were determined using the Transformation Analysis feature with its compute variable aspect that ensures easy defining of parameters (Fig. 1).

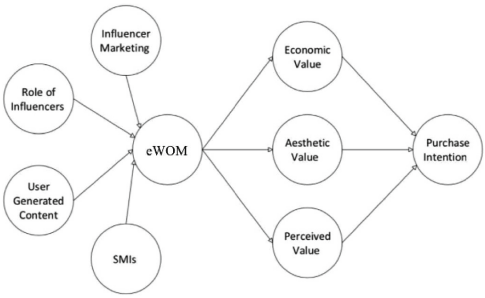

Fig. 1. Conceptual Model (source: Owners proposed model)

6 Results and Discussion

The influential aspects are clubbed into three main categories or factors namely, Aesthetic Value, Economic Value and Perceived Value based on their commonalities in the Table 1 (Table 2).

The KMO and Bartlett's Test here confirms that the sample size considered is of an ideal size and is good enough to run analyses on. Additionally, it confirms that the variables involved are useful and correlated since the significance value (p value) determined is 0.000 that is less than 0.05 (Table 3).

It may be interpreted here that reviews form an important part of the consumer decision making on budget hotels (Table 4).

Regression Analysis:

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.408[a]	.167	.132	1.09023

[a]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.

It may be interpreted here that the following influencers are able to capture the market with their posts in terms of Economic Value: Shivya Nath, Archana Singh, Siddhartha Joshi, Dheeraj Sharma. Thus, through these influencers, consumers feel a sense of gaining information around the value for money features (Tables 5, 6 and 7).

Table 1. Data analysis and Interpretation

Rotated Component Matrix			
	1	2	3
Location and Accessibility	0.036	0.685	0.465
Prices	0.013	0.795	0.089
Package / Combination Offerings	0.316	0.654	-0.323
Amenities	0.564	0.539	0.188
Space and Aesthetics (Interiors and Exteriors)	0.826	0.225	-0.056
Past Experiences	0.889	0.064	0.064
Online Review Consideration	0.183	0.088	0.862
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.	Aesthetic Value	Economic Value	Perceived Value
a. Rotation converged in 4 iterations.			

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.731
Bartlett's Test of Sphericity	Approx. Chi-Square	564.591
	Df	28
	Sig	.000

Table 3. Component Analysis

	Initial	Extraction
Location and Accessibility	1.000	.688
Prices	1.000	.641
Package/Combination Offerings	1.000	.632
Amenities	1.000	.644
Space and Aesthetics (Interiors and Exteriors)	1.000	.736
Reviews	1.000	.806
Past Experiences	1.000	.798
Online Review Consideration	1.000	.784

Extraction Method: Principal Component Analysis.

Table 4. ANOVA test

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	45.398	8	5.675	4.774	.000[b]
	Residual	227.024	191	1.189		
	Total	272.422	199			

[a]Dependent Variable: Ecovalue.
[b]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.
Table 8 – Economic Value (ANOVA).

Table 5. Aesthetic Value (Model Summary)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.624[a]	.389	.364	1.36094

[a]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.

Table 6. ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	225.316	8	28.164	15.206	.000[b]
	Residual	353.760	191	1.852		
	Total	579.076	199			

[a] Dependent Variable: Aestvalue.
[b]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.

Thus, through these influencers, consumers feel a sense of gaining information around the aesthetic and auxiliary features (Tables 9 and 10).

Thus, through these influencers, consumers feel a sense of gaining information around the services, authenticity, quality and more regarding the budget hotel accommodation.

With the goal of understanding the impact that micro influencers have on consumer decision making on budget hotels in the Indian context, this study was set out to understand the role that micro influencers play in the consumer decision making on budget hotels, gain insights on the importance and usefulness of user-generated content, find out if social media has an impact on consumer decision making, and understand the reasons behind the conversion of consumers' purchase intentions to actual purchase actions.

Eventually, the hypotheses were proven to be true based on the research findings and references. Thus, from the results, we can conclude that micro influencers greatly impact consumer decision making on budget hotels in India.

Table 7. Aesthetic Value (ANOVA)

Model		Unstandardized Coefficients		Standardized Coefficients Beta	T	Sig.
		B	Std. Error			
1	(Constant)	1.711	.263		6.493	.000
	Micro Influencer 1	−.038	.084	−.045	−.452	.651
	Micro Influencer 2	−.092	.080	−.098	−1.143	.255
	Micro Influencer 3	.022	.089	.023	.246	.806
	Micro Influencer 4	.055	.090	.060	.619	.536
	Micro Influencer 5	.072	.103	.082	.698	.486
	Micro Influencer 6	−.015	.075	−.020	−.194	.846
	Micro Influencer 7	.212	.082	.325	2.598	.010
	Micro Influencer 8	.138	.056	.235	2.460	.015

[a] Dependent Variable: Aestvalue.
Table 12– Aesthetic Value (Coefficients).

Table 8. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.358[a]	.128	.092	.99915

[a]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.
Table 13 – Perceived Value (Model Summary).

However, it may be considered that the Indian market is one that is still growing with its citizens slowly yet actively adapting to digital forums and new-age marketing tools. Therefore, micro influencer marketing, though taking the hospitality markets by storm, still is an emerging facet of marketing in the country and will take a few more years to gain the mainstream momentum it strives for. Based on the results received and interpreted in the preceding sections, the following recommendations may be made:

- Budget hotels must engage with micro influencers since they have the desired reach that may be benefited from at affordable rates, easily and quickly

Table 9. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.044	8	3.506	3.512	.001[b]
	Residual	190.676	191	.998		
	Total	218.720	199			

[a]Dependent Variable: Online Review Consideration.
[b]Predictors: (Constant), Micro Influencer 8, Micro Influencer 1, Micro Influencer 4, Micro Influencer 2, Micro Influencer 6, Micro Influencer 3, Micro Influencer 5, Micro Influencer 7.
Table 14 – Perceived Value (ANOVA).

Table 10. Perceived Value (Coefficients)

Model		Unstandardized Coefficients		Standardized Coefficients Beta	T	Sig.
		B	Std. Error			
1	(Constant)	1.275	.193		6.593	.000
	Micro Influencer 1	.002	.062	.003	.026	.980
	Micro Influencer 2	.005	.059	.008	.078	.938
	Micro Influencer 3	.024	.066	.042	.371	.711
	Micro Influencer 4	.036	.066	.064	.550	.583
	Micro Influencer 5	.148	.075	.276	1.965	.051
	Micro Influencer 6	.001	.055	.003	.026	.980
	Micro Influencer 7	−.147	.060	−.368	-2.458	.015
	Micro Influencer 8	.115	.041	.318	2.787	.006

[a]Dependent Variable: Online Review Consideration.

- Budget hotels must identify their target audiences and choose the appropriate kind of micro influencers
- It is important for budget hotels to consider and respond to reviews received by them from guests in general, either in person or online, since: Indians consider online reviews to a great extent while choosing budget hotels. Any guest may just be a micro influencer who may post about the stay, services, amenities, experience, accessibility, aesthetics, surroundings and more

- User generated content is important to a certain extent and so engagement through such an avenue in collaboration with micro influencers may seem to be beneficial.

In the current times, social media plays a huge role in the consumer decision making and so it is essential for budget hotels, specifically, considering their smaller scales, to create and maintain attractive social media feeds, potentially taking help from micro influencers to ease the process.

7 Limitations and Scope for Further Research

The study suggest the possibilities of the micro influencers greatly impacting the consumer decision making process on budget hotels and how they achieve this. However, it also entails certain limitations that it faced during the research process that may be considered as elaborated on under: The concept of micro influencer marketing is a relatively new one to the Indian market, especially since it consists of an array of demographics and technology acceptance levels. This emphasizes the fact that a lot of the citizens:

- may not be aware of this facet of marketing and so may not be accessing its content portals.
- may have reservations on believing such content and so may prefer their own cognitive decisions based on the knowledge they possess.

Furthermore, a lot of research has not been conducted in this area of micro influencer marketing and so much reference material within the country is not available, resulting in there having been certain roadblocks and uncertainties during the process:

The sample involved in this study is limited in terms of its size (200 individuals) and potential reach considering it being at a small level as part of an educational undertaken, inhibiting resources and relatively less time available. Considering it being a relatively newer discipline, especially in India, a lot of literature that may be used to conduct secondary research is not widely available and so significant amounts of secondary data to validate the primary research findings has not been included. Owing to the scale of the project, and resources and time available, this study does not include interactions with influencers and marketing teams at budget hotel brand chains. Potential interactions with these entities may have further validated the results, giving dimensions to it.

This research is an interesting one to undertake and revise in the future as per the dynamic changes that the industries of marketing hospitality involved experience at a regular basis. Therefore, a more in depth exploration on the topic and subject backed by detailed secondary research and personal interview sessions with micro influencers as well as personnel from the budget hotels landscape, may prove to be beneficial at a deeper level to the entities closely working around this, for them to be able to better produce results and achieve targets. Moreover, a larger sample size and wider reach may potentially add a more relatable dimension to the study.

8 Conclusion

Based on the analysis results and their interpretations, the following patterns emerged among the respondents: Age: The majority of respondents fall within the 18 to 33 years old age group. Gender: Both male and female respondents participated in the survey.

Occupations: The surveyed individuals primarily consist of students and professionals. Family Size: Most respondents have approximately four members in their families. Income: Respondents' incomes vary, with a significant portion earning between INR 0 to 3 Lakhs or more than INR 9 Lakhs. Location: The majority of respondents are from Tier 1 and Tier 2 cities. Travel Habits: They tend to travel mainly for vacations to different cities based on their interests.

Based on these findings, it can be concluded that these individuals: Are somewhat familiar with budget hotels, with OYO hotels being a prominent choice. They also recall budget arms of luxury brands. Consider factors such as price, value for money, location, accessibility, past experiences, and reviews from various sources, including friends and family, when making decisions. These factors encompass economic value, aesthetic value, and perceived value. Prefer to seek information about budget accommodations and tourism opportunities on Instagram and travel websites. Regard information about space, amenities, and costs as crucial when consuming content from micro-influencers about budget hotels. Therefore, it is evident that consumer decisions regarding budget hotels are influenced by content posted by micro-influencers, making them valuable for such accommodation providers. However, it is important to note that these characteristics may not apply universally to all individuals of this demographic. Consequently, budget hotels should:

- Identify their target audiences in advance.
- Determine the type of content that aligns with their brand values and philosophy.
- Select appropriate micro-influencers and clearly communicate their expectations.
- Continuously monitor reviews and visitor trends with a flexible approach, given the dynamic nature of operating environments.

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The Impact of the Metaverse on Green Marketing: A Paradigm Shift in Sustainable Consumer Behaviour

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Abstract. The rise of the metaverse has attracted a lot of interest as technology improvement keep transforming how we interact and engage with the virtual world. The term "metaverse" denotes an interactively simulated world in which individuals have the ability to engage with an artificially created setting along with other users in real time. The primary objective of the present study is to examine the possible implications of the metaverse on green marketing, with a special emphasis on its effects on sustainable consumption behaviour. Through a comprehensive analysis of the metaverse's distinctive attributes, potential advantages, and inherent obstacles, our objective is to ascertain the extent to which this emerging digital realm might effectively facilitate the progress of ecologically sustainable products as well as behaviours of consumers. Furthermore, we analyze the potential implications for businesses and marketers in utilizing the metaverse as a means to augment their environmentally conscious advertising approaches.

Keywords: Metaverse · green marketing · sustainable consumption behaviour · virtual reality

1 Introduction

With the increasing adoption of digital devices in several facets of human existence has led to the emergence of virtual worlds [1]. One of the most recent advancements in the domain of digital technology is the emergence of the metaverse, a highly immersive virtual environment that facilitates real-time interactions among users and digital content [2]. Metaverse represents a convergence of digital environments incorporating augmented reality (AR) and virtual reality (VR), hence creating a globally accessible collective virtual shared place. Where, digital avatars have the capability to partake in a wide range of activities, including interactions, professional tasks, retail transactions, educational pursuits, and involvement in communal events [3]. The metaverse revenue opportunity was recorded in 2020 as about $500 billion; it is estimated to reach $800 billion in 2024 [4]. Due to its immersive and interactive nature, has the potential to change conventional marketing approaches and affect customer attitudes and behaviours towards

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sustainable consumption [5]. With the growing importance of sustainability in the minds of consumers, companies are facing growing demand to embrace eco-friendly practices and effectively convey their commitment to sustainability [6]. However, conventional marketing techniques may be inadequate in effectively engaging and motivating customers toward making sustainable choices. The metaverse is a distinctive platform that has the potential to overcome this divide and offer novel prospects for green marketing. [7]. The potential benefits of the Metaverse extend beyond environmental considerations, particularly in relation to the mitigation of real-world travel demands through the facilitation of virtual business meetings. Furthermore, the implementation of the metaverse has the potential to promote the practice of remote working, therefore mitigating the adverse impacts of pollution [8]. The metaverse has the potential to mitigate carbon emissions related to transportation [9] and the maintenance of office buildings. All of these factors have the potential to reduce environmental damage. According to a study conducted by multinational professional services firm Ernst & Young, making a digital twin structure in the metaverse and integrating machine learning (ML) and artificial intelligence (AI) will allow for up to 50% savings in energy consumption and costs throughout the building's life cycle [10]. For example, Major corporations involved in designing the metaverse have publicly declared their commitment to the promotion of sustainable technologies. This includes efforts to optimize both hardware and software components in order minimize energy consumption and mitigate CO2 emissions. Additionally, these companies are exploring the effective use of renewable energy sources such as solar power to support their operations. The implementation of various sustainable strategies might provide substantial consequences in mitigating adverse environmental effects [10–14].

In addition, the metaverse, a digitally immersive universe that enables limitless opportunities for interaction, engagement, and creativity, has the potential to significantly transform green marketing techniques. Business enterprises have the potential to utilize the Metaverse as an innovative medium for showcasing their commitment to sustainability, effectively interacting with ecologically concerned customers, and demonstrating the real-time environmental consequences of their operations or merchandise. Furthermore, Metaverse potential contribution towards environmental Sustainability is monumental. By predicting and precisely aligning to demand, AI can prevent Overproduction—a significant cause of material and energy waste in the fashion industry. Additionally, the adoption of AI-assisted 3D Printing allows for reduced transportation Emissions and minimized fabric waste. An AI System that tracks and verifies sustainable Practices can enforce accountability for the industry's environmental impact, compelling Brands to invest in green initiative [15, 16]. This use of the Metaverse can lead to improved transparency and trust among stakeholders [17]. Nevertheless, despite the alluring possibilities, there has been a dearth of conceptual study exploring the intersection of sustainability, green marketing, and the metaverse, hence creating a fertile area for further investigation. This study aims to address the existing research gap by examine the possible implications of the metaverse on green marketing, with a special emphasis on its effects on sustainable consumption behaviour. Our research aims to provide insight into the emergent possibilities and difficulties in order to assist businesses in navigating this intriguing but unexplored territory. The interplay of sustainability principles with

these transformative technologies has the potential to open up new avenues for green marketing.

2 Methodology

The present study employs a technique that involves conducting a comprehensive assessment of contemporary scholarly literature pertaining to the metaverse and green marketing. The process of seeking content encompasses a wide range of sources, including internet resources, scholarly publications, and book chapters. References are mostly derived from a range of internet sites, including but not limited to Web of Science, Scopus, Science Direct, Google Scholar, and several other sources. The advanced search function is restricted to the phrases Metaverse, artificial intelligence, virtual reality, augmented reality, as well as green marketing and sustainable consumption. The majority of the citations are derived only from scholarly articles, book chapters, and full-text documents. Furthermore, the references consider the global advancements in the metaverse from 2008 to the current year, 2023. The chosen technique is well-suited for this study due to its relevance in conceptual development and its applicability to interconnected sections or strands of literature [18]. Consequently, by a comprehensive examination of pertinent existing scholarly works, researchers are able to substantiate the suggested definition and evaluate the imminent possibilities of the metaverse and green marketing strategy, as demonstrated below.

3 The Metaverse: Concept and Characteristics

3.1 Definition and Evolution

The word metaverse has been subject to varying interpretations and applications by researchers [19]. Initially characterized it as an internet-based environment that serves as both a virtual realm and a tangible space whereby individuals may engage in social interactions, pursue commercial endeavors, and seek entertainment, employing the physical world as a metaphoric context. However, during that period, the technical feasibility of constructing the metaverse was absent. [20], metaverse refers to immersive 3D digital virtual environments that facilitate individuals to inhabit and construct their identities by means of avatars and digital representations of themselves. The integration of private and public utilities in a lifelike manner has the potential to expand the boundaries of physical reality into a virtual space on internet. The concept of the Metaverse encompasses a combination of many technologies that aim to provide novel learning situations and experiences. [21] conceptualized the term metaverse as "metaverse" refers to a computer-generated universe that exists beyond real life. This realm is characterized by completely immersive 3D virtual surroundings, which encompass every aspect of shared online space across all dimensions of representation.

This section explains how researchers have defined and used the term metaverse before and after 2020. From late 2000s to mid-2010s, researchers have discussed the term metaverse across digital or virtual settings such as gamifications and avatar-based learning platforms. The term "metaverse" refers to a virtual reality space where users

can engage and interact with digital content in a simulated environment. Coined by Neal Stephenson in his 1992 science fiction Stephenson development, has resulted in the inconsistent application of the term [22, 23]. Despite the existence of multiple conceptions put forth by business professionals and scholars, it is widely acknowledged that a universally accepted definition of the Metaverse still lacks [24]. Unlike [25], who define the Metaverse as "a persistent and constantly updated collection of mixed reality spaces mapped to various geospatial locations." Ball (2022) defined metaverse as "a massively scaled and interoperable network of real-time rendered 3D virtual worlds and environments, which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments". Furthermore, [26] described Metaverse as a network of digitally mediated places that immerse people in shared, real-time experiences. Notably, this paradigm indicates five essential Metaverse characteristics: it is (1) digitally mediated, (2) spatial, (3) immersive, (4) shared, and (5) real-time. Moreover, [27] define metaverse retailling as a "digital environment that employs emerging technologies such as augmented reality (AR), virtual reality (VR), and blockchain." It also uses social media concepts to create areas for user interaction, providing a more realistic experience. The three pillars of retail Metaverse that will enhance the brand's capacity to pull actual, human customers along on this digital journey are community, experience, and engagement.

3.2 Key Features of the Metaverse in Green Marketing

The Metaverse, commonly linked to virtual reality and immersive encounters, has considerable promise in the realm of green marketing, a discipline centered on the promotion of ecologically sustainable products and behaviours. The following are many significant features of the Metaverse in the context of green marketing:

- Virtual Sustainability Education: The use of the Metaverse has the potential to serve as a medium for engaging and collaborative sustainability-related education. Individuals have the opportunity to engage with virtual settings that simulate real-world ecosystems, enabling them to acquire knowledge pertaining to sustainable methodologies, renewable energy alternatives, and initiatives focused on preserving natural resources. The inclusion of a learning aspect has the potential to enhance persons' understanding and consciousness regarding environmental issues, hence motivating them to embrace sustainable behaviours [28].
- Sustainable Product Showcasing: Companies have the opportunity to utilize the Metaverse as a platform to exhibit their sustainable products and services. Virtual showrooms and exhibits provide customers with the opportunity to engage with and immerse themselves in eco-friendly items, including but not limited to electric automobiles, renewable energy solutions, and sustainable fashion. The utilization of virtual showcasing has the potential to elicit curiosity, foster participation, and eventually stimulate demand for environmentally sustainable solutions [29].
- Virtual Collaboration and Co-creation: The Metaverse facilitates the process of cooperation and co-creation among individuals situated in diverse geographical areas. This particular element has the potential to enhance collaborative activities aimed at

sustainability through the facilitation of idea exchange, information dissemination, and collaborative undertakings centered around environmentally friendly activities. Virtual workshops, conferences, and brainstorming sessions have the potential to expedite the process of innovation in sustainable practices and ideas [30].

- Gamification of Sustainable Behaviors: The Metaverse's immersive and interactive qualities present a potential avenue for the gamification of sustainable behaviours. The use of virtual challenges, quests, and successes has the potential to incentivize individuals to embrace and sustain environmentally conscious behaviours in their tangible day-to-day existence [31].

3.3 Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) in the Metaverse

In the Metaverse, virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies are believed to have substantial impacts on the development of immersive and engaging experiences [32]. Virtual reality (VR) technology allows anyone to immerse themselves in a fully computer-generated world by utilizing head-mounted screens and motion-tracking tools [33]. Within the domain of the Metaverse, the utilization of virtual reality (VR) technology offers individuals the capacity to be moved to virtual realms that closely imitate reality. This immersive experience allows users to interact with the virtual environment and other participants in a very engaging manner [21]. Virtual reality (VR) possesses the potential to provide an enhanced perception of being present and realistic, hence enhancing the entire immersive encounter within the Metaverse [34]. Augmented reality (AR) refers to a technological innovation that combines interactive data into the physical space, effectively blending virtual elements with the real world. In the context of the Metaverse, augmented reality (AR) has the potential to enable the smooth incorporation of digital content and experiences into users' physical surroundings [35]. Individuals possess the capacity to interact with digital stuff, such as holograms or virtual avatars, while concurrently preserving awareness and affiliation with their tangible surroundings [36]. Mixed reality (MR) refers to an immersive technological approach that combines elements from virtual reality (VR) and augmented reality (AR), so creating a spectrum that encompasses the whole range from total virtuality to complete reality. Mixed reality (MR) allows to facilitate the seamless integration of virtual elements into the physical world, enabling their interaction with one another and immediate reaction in real-time [37] Within the Metaverse, The use of Mixed Reality (MR) technology in the Metaverse enables users to connect with simulated objects and individuals in their real-world environment, hence enhancing the degree of immersion and engagement [38]. Through the integration of various immersive technologies, the Metaverse possesses the capacity to generate complex and dynamic encounters that obscure the difference between the virtual and physical domains. It is important to acknowledge that the precise implementation and integration of virtual reality (VR), augmented reality (AR), and mixed reality (MR) inside the Metaverse may exhibit variations and undergo transformations as technology progresses and novel advancements arise.

4 Green Marketing: Concepts and Importance

4.1 Definition and Evolution

Green marketing, also referred to as ecological marketing or environmental marketing, encompasses various advertising strategies that explicitly or implicitly claim to offer ecological advantages [39]. The initial conceptualization of Green Marketing can be traced back to 1976, as Hennion and Kinnear (p. 1) emphasized the significance of Ecological Marketing. They defined it as encompassing all marketing activities that contribute to the emergence of environmental issues, while also offering potential solutions to address such issues [40]. Over the course of time, numerous definitions have been proposed, leading to the gradual refinement and establishment of a more organized framework, as indicated by [41] definition of Sustainable Marketing, it encompasses the strategic activities of planning, executing, and monitoring the progression of product development, pricing, promotion, and distribution. The primary objective of Sustainable Marketing is to fulfill three essential criteria: (1) meeting customer needs, (2) achieving organizational goals, and (3) ensuring compatibility with ecosystems. The provided statement emphasizes the significance of Green Marketing in relation to cleaner production and corporate sustainability. [42] conducted an analysis of the evolutionary progress of green business and the underlying factors that encouraged the development of green marketing. [44] conducted a study that examined the progression of the concept of green marketing and the distinct actions associated with it during every step of its evolution. [43] recognized that green marketing should not regarded as a mere extension of traditional marketing. Utilizing a more case-oriented methodology [45] examined a various instance of green products failure, indicating factors that must be considered when designing and marketing green products. Particularly, the authors emphasized that green marketing must meet two objectives at the same time: design products with high environmental quality and meet customer expectations. [46] defines successful Green Marketing as "the application of ethical advertising ideas to make green products desirable for consumers," whereas [47] define eco-marketing as "the alignment of consumer interests with environmental requirements."

4.2 The Rise of Sustainable Consumer Behavior

The phenomenon of sustainable consumption behaviour has experienced a notable increase in the past few years, indicating a growing recognition of social and environmental issues among consumers. This phenomenon is demonstrated by the growing inclination towards environmentally sustainable products, the embrace of minimalist way of life, and the prioritization of ethically produced goods. Based on the findings of the economic study conducted by [48], it has been observed that a significant proportion, specifically 54%, of individuals residing in both developed and developing nations have made a transition in their food choices towards environmentally sustainable consuming practices. The adoption of a pro-environmental stance is having a positive impact on the preservation, sustainability, and production of the environment [49]. The above shifts are further supported by research conducted by [50] and published in the Journal of Cleaner Production. The study reveals a growing inclination among customers

to allocate more funds for items that possess environmental certifications, hence signifying a trend towards environmentally conscious purchasing choices. The increase in sustainable consumption habits can be attributed to a combination of factors, including improved access to knowledge on the negative consequences of over consumption and the detrimental effects of particular production techniques on ecosystems [51]. The dissemination of information and the promotion of environmentally aware activities have been significantly influenced by social media platforms, motivating consumers to adopt more sustainable behaviours in their everyday activities [52]. Governments and international organizations have been instrumental in fostering sustainable consumption behaviour. The Intergovernmental Panel on Climate Change (IPCC) emphasized the necessity for rapid and significant reductions in greenhouse gas emissions [53, 54] to keep global warming to 1.5◦ Celsius. Sustainable consumption is one of the Sustainable Development Goals (SDGs), which covers minimizing harmful environmental and health impacts and promoting ecofriendly lifestyles [55, 56]. The European Union (EU) proposed a European Green Deal, which aims to make sustainable products the norm in the EU, promote circular business models, and empower consumers for the green transition [57]. As a result of the new requirements, products have to be more environmentally friendly, durable, reusable, repairable, upgradeable, easier to maintain, refurbish, recycle as well as be energy and resource-efficient [58].

5 The Intersection of Metaverse and Green Marketing

The metaverse, integrates physical and digital worlds into a unified virtual environment, is expected to have a substantial impact on the evolution of green marketing methods and the promotion of sustainable consumer behaviours [59]. The utilization of AI within the Metaverse holds significant implications for sustainable consumption through the facilitation of particular suggestions, efficient resource allocation, and enhanced decision-making processes. AI algorithms have the capability to analyze user data and preferences in order to offer personalized recommendations for sustainable products and services. This has the potential to impact consumer behaviour by encouraging them to make more environmentally friendly choices [60]. Furthermore, AI-driven systems have the capability to optimize energy consumption, minimize resource wastage, and improve operational effectiveness, hence making significant contributions towards sustainability initiatives across diverse industries [60].

For instance, High numbers of returns in the apparel industry result in a lot of waste and misuse of resources. One novel solution to this challenge is AI-powered virtual fitting rooms. Customers can use these technologies to build digital avatars based on their Measurements, allowing them to digitally “try on” Garments [61–64].AI gives an immersive, realistic fitting experience using image recognition and visualization technologies. Returns due to sizing or fitting difficulties are considerably decreased with a realistic picture of how the Garment will look and fit on the individual [60]. This technique contributes significantly to sustainability by minimizing waste associated with returns. Further, Metaverse has the potential to facilitate the identification and advancement of sustainable textiles. By employing machine learning techniques, it is possible to train models to analyze and evaluate a vast database of materials, enabling the selection

of environmentally conscious solutions. This capability may assist businesses in their endeavors to develop more sustainable lines of production.

Gamification in the metaverse has the ability to incentivize the adoption of sustainable consumption habits. The implementation of gamified components such as challenges, rewards, and contests focusing on eco-conscious behaviours has the potential to boost engagement and happiness associated with adopting sustainable consumer behaviours [65]. This method combines intrinsic motivation and psychological clues to actively engage people in environmentally friendly efforts. The metaverse's ongoing evolution provides an opportunity to apply green marketing methods, with the potential to create large positive changes in consumer behaviour. This link with worldwide endeavors aimed at fostering a sustainable future is noteworthy.

To summarize, the metaverse offers an excellent potential for promoting green marketing techniques and supporting sustainable consumer behaviours. The metaverse can raise environmental awareness and encourage positive behavioural changes through immersive interactions, collaborative communities, gamification, and brand integration. Given the increasing impact of technology on human interaction and consumption, it is critical to investigate the impact of metaverse on green marketing and sustainable consumption behaviour.

6 Real Used Cases of Metaverse in Green Marketing

Due to companies' increased interest in innovative ways to improve sustainability and environmental awareness, green marketing has increasingly used the metaverse. A noteworthy example involves Leading online garment store ASOS used AI in their "See My Fit" virtual fitting room. The technology allows shoppers see how a garment might look on models of varying sizes, replicating real-world body range. This unique feature helps consumers see how the item will appear on them, decreasing the risk of erroneously purchases and returns. This reduces return waste and emissions, making shopping more sustainable and resource-efficient [66, 67]. Furthermore, Tommy Hilfiger initiated the "Reimagine Retail" initiative, an innovative endeavor, in partnership with IBM and the Fashion Institute of Technology (FIT). In order to identify and comprehend new fashion trends, this study used AI [68]. The AI-powered trend analysis helped to generate concepts for fresh designs that complemented these progressive tendencies. As a result, the brand was able to design a distinctive fashion line that was both in line with anticipated market tastes and centered around sustainability [69]. The Tommy Hilfiger brand demonstrated how AI can be used to effectively integrate sustainability into even the creative processes of fashion, proving beneficial to both the business and the environment. This was achieved by reducing waste in production by accurately anticipating and meeting future consumer demand. Another promising real lifer example. In collaboration with Intel, Levi's used AI to provide an enhanced personalized shopping experience. Using Intel-developed techniques, Levi's was able to analyze each customer's purchasing and browsing history [70]. Based on this, the AI-powered virtual stylist provided real-time, personalised recommendations that were tailored to the consumers' specific style preferences. This strategic approach increased customer happiness by providing a more intuitive and seamless purchasing experience. More importantly, it encouraged

customers to make more thoughtful purchases, lowering impulsive purchases and boosting the longevity of the clothing purchased, so advancing Levi's commitment to retail sustainability. Lastly, H&M, tech-forward company in fashion, uses AI improves inventory management and sustainability. Their "smart stocking" technique employs predictive analytics to analyze all sales data from their stores, online and offline. This smart algorithm can anticipate garment popularity and design a customized inventory list for each business based on local buying behaviours and trends. Making ensuring every item produced has the greatest sales potential reduces overproduction. Since each store maintains a customer-specific inventory, it reduces the need for wasteful clothing transfers. This reduces transportation emissions and boosts sales by stocking every store with customer-preferred merchandise.

7 Opportunities and Challenges for Green Marketing in the Metaverse

7.1 Opportunities

The metaverse presents plenty of promising prospects for the domains of green marketing and the growth of ethical buying behaviour. This virtual landscape presents an innovative and engaging platform to drive positive environmental change. Firstly, the metaverse facilitates fully immersive experiences that possess the capacity to significantly impact consumer behaviour [71]. Brands have the ability to develop virtual simulations that depict eco-friendly practices, such as recycling or organic farming, enabling people to actively engage and get a more profound comprehension of these activities. Furthermore, the metaverse enables the formation of sustainable communities [72]. Individuals who possess a common commitment to ecological consciousness have the opportunity to convene in digital environments for the purpose of exchanging ideas, disseminating tales of success, and engaging in collective activities pertaining to sustainability initiatives. These communities offer a nurturing atmosphere for those seeking to embrace more environmentally conscious lives, fostering a sense of inclusion and encouragement to persist in their pursuit of sustainability [73]. By engaging in collective experiences and dialogues, individuals may augment their comprehension of sustainable consumption and foster a culture of environmental responsibility, therefore motivating one another to make conscious decisions [74].

Furthermore, the integration of gamification inside the metaverse has the potential to provide incentives for the adoption of sustainable behaviour [65]. Through the incorporation of game components such as obstacles, incentives, and contests centered around ecofriendly acts, individuals are encouraged to actively engage in environmentally conscious initiatives [75]. This strategy leverages individuals' intrinsic drive for success and competition, rendering sustainable practices both pleasurable and interesting.

Moreover, enterprises have the opportunity to utilize the metaverse as a platform for demonstrating their dedication to sustainable practices. Virtual stores and exhibits have the potential to showcase environmentally friendly products and supply chains that are characterized by transparency, so empowering customers to make well-informed decisions [76]. Interactive storytelling may be employed by brands as a means of effectively

conveying their sustainability journey and motivating people to make conscientious purchase choices. This phenomenon can give rise to a positive feedback loop, wherein people exhibit a higher propensity to endorse and advocate for businesses. In summary, the metaverse offers several prospects for advancing green marketing and fostering sustainable consumer behaviour [77].

7.2 Challenges

The implementation of green marketing and the promotion of sustainable consumer behaviour in the metaverse provide inherent challenges that must be duly acknowledged and resolved in order to achieve optimal effectiveness. One prominent obstacle is to the phenomenon of "greenwashing," when corporations in the metaverse make deceptive assertions about their ecologically sustainable practices without implementing substantial real-world measures. This might result in a sense of skepticism among customers [78]. The virtual aspect of the metaverse may potentially create a sense of detachment when individuals participate in sustainability-oriented activities inside the virtual sphere but struggle to implement those behaviours in their offline existence [78]. This underlines the significance of creating a connection between digital engagement and practical adjustments in behavior. Furthermore, the matter of privacy and data security in the metaverse gives rise to doubts regarding the ethical consequences of personalized green marketing activities.

The proper management of personal information and the possibility for manipulative practices are subjects of concern when corporations collect and employ user data to customize sustainability related material. [79] conducted a comprehensive investigation on the subject of online privacy issues and emphasized the need of upholding consumers' confidence within augmented reality. In summary, the Metaverse poses multiple barriers to green marketing and sustainable consumer behaviour, including difficulties such as greenwashing, behavior-action discrepancies, information saturation, the digital divide, and concerns around privacy. To tackle these problems, a comprehensive strategy is necessary, encompassing transparent discourse, effective behavior-change techniques, careful collection of information, and ethical data practices. This approach aims to cultivate authentic involvement and promote favorable environmental outcomes.

8 Implication

The development of the metaverse in the past few decades carries significant implications for advertisers and businesses aiming to augment their green marketing strategies. To start, the metaverse presents a distinctive and authentic platform for the creation of storytelling and the active involvement of viewers. Marketers have the capacity to utilize this technology in order to craft appealing stories that emphasize their devotion to sustainability, successfully showcasing sustainable practices, products, and efforts. Companies have the ability to create experiential marketing activities that effectively captivate consumers by utilizing the interactive features of the metaverse, so developing a deeper emotional connection with environmental concerns and sustainable solutions.

Furthermore, the metaverse subsequently facilitates the implementation of personalized and targeted marketing approaches. Marketers have the ability to customize eco-friendly advertisements based on various preferences through the utilization of data analysis and an understanding of consumer behaviour. This practice serves to enhance the importance and effectiveness of their marketing efforts. Furthermore, the metaverse serves as a platform for the formation of virtual communities dedicated to the promotion of sustainability. Businesses can create brand-aligned virtual spaces that provide gathering places for people who share similar values to join in discussions, share information, and work on environmentally beneficial projects. These online networks serve as crucial centers for information exchange, peer support, and collaborative projects, greatly increasing the effect and reach of green marketing initiatives.

Furthermore, the metaverse enables the design of deep experiences for organizations that successfully integrate virtual and real-world behaviour. Marketers have the opportunity to improve the effectiveness of sustainability programmes by incorporating attributes that drive people to convert their virtual sustainable acts into concrete behaviours.

Nonetheless, marketers face the problem of addressing questions regarding authenticity and credibility. Privacy and security concerns are equally important. Businesses must priorities ethical data management while collecting and using personal data in the metaverse, respecting users' privacy rights. Using strong data protection measures can assist mitigate the detrimental effects of confidentiality issues on the efficacy of long-term sustainability projects. To summaries, the metaverse's impact on environmentally conscious consumer behaviour, gives marketers and businesses with a dynamic place to interact in and influence environmentally responsible decision-making. Businesses can present themselves as leaders devoted to sustainability by providing immersive experiences, honest communication, collaborative communities, and ethical behaviour.

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