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Research Article

An investigation of metaverse adoption for SMEs in Bangkok through the Technology-Organization Environment (TOE) framework

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Abstract: The adoption of Metaverse technologies has gained increasing attention as digital platforms become more prevalent in business and social interaction. This study investigates the determinants of Metaverse adoption intention among small and medium-sized enterprises (SMEs) in Bangkok, focusing on technological, organizational, and environmental factors. Data were collected from 240 SME participants using purposive sampling through structured questionnaires. Confirmatory Factor Analysis (CFA) verified the reliability and validity of the measurement model, while Structural Equation Modeling (SEM) examined the relationships among latent constructs. Results indicate that technological factors, including system readiness, security, and visual appeal, exert the strongest positive influence on adoption intention. Organizational factors, such as reduced anxiety, collective awareness, and word-of-mouth, also significantly affect adoption, highlighting the importance of social and organizational support within SMEs. Environmental factors, including technology investments, social influence, and vendor support, further positively impact adoption intention, emphasizing the role of external facilitation. The full SEM model demonstrated good fit, with $\chi^2/df = 2.25$, CFI = 0.94, TLI = 0.93, RMSEA = 0.059, and SRMR = 0.048, confirming that the proposed model adequately represents the relationships among constructs. This study contributes empirical evidence on multidimensional determinants of Metaverse adoption within SMEs, supporting the Technology–Organization–Environment (TOE) framework. Practically, the findings provide guidance for SME managers and platform developers to enhance technological readiness, foster organizational support, and strengthen environmental facilitation to encourage adoption. Future research may explore moderating and mediating variables, cross-cultural comparisons, and longitudinal adoption patterns to gain deeper insights into engagement with immersive digital platforms.

Keywords: Metaverse adoption; Technology–Organization–Environment (TOE); SMEs

1. Introduction

The integration of the Metaverse into Small and Medium-sized Enterprises (SMEs) in Bangkok is gaining momentum, driven by the increasing need for digital transformation and competitive advantage. Globally, studies employing the Technology-Organization-Environment (TOE) framework have identified key factors influencing Metaverse adoption. For instance, research by Hasani et al. indicates that technological readiness, organizational support, and environmental pressures are significant determinants of SMEs' intention to adopt Metaverse technologies. Similarly [1], highlight that the Metaverse can enhance marketing capabilities of retail SMEs by providing immersive customer experiences and new sales channels. These findings suggest that SMEs in Bangkok can leverage the Metaverse to improve customer engagement and operational efficiency. However, challenges such as technological complexity and resource constraints may impede adoption. Therefore, understanding the TOE framework's application is crucial for SMEs in Bangkok to navigate the complexities of Metaverse adoption effectively.

The adoption of the Metaverse is anticipated to significantly influence global economic and social landscapes. Economically, estimates suggest that the Metaverse could contribute up to $3.6 trillion annually to global GDP by 2035, driven by advancements in immersive technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) [2]. This growth is expected to stem from new business models, enhanced productivity, and the creation of virtual marketplaces. Socially, the Metaverse has the potential to democratize access to education, healthcare, and employment, offering immersive and interactive experiences that can bridge geographical and socio-economic divides [43]. However, these advancements also raise concerns regarding digital equity, privacy, and potential increases in screen time, which may impact mental and physical well-being [3]. Therefore, while the Metaverse presents substantial opportunities for economic and social development, it also necessitates careful consideration of its implications to ensure inclusive and sustainable growth.

In Thailand is fostering significant economic and social transformations, particularly among Small and Medium-sized Enterprises (SMEs). Research indicates that integrating Metaverse marketing strategies can revitalize traditional industries and enhance community development by providing immersive experiences that attract both local and international consumers [4]. Additionally, studies have shown that SMEs in Thailand are increasingly adopting Metaverse technologies to improve customer engagement and operational efficiency, leading to enhanced business performance [5]. However, challenges such as technological readiness, cost, and the need for digital skills development remain barriers to widespread adoption [4]. Addressing these challenges through targeted policies and support mechanisms is crucial for maximizing the potential benefits of the Metaverse in Thailand's economic and social development.

Research indicates substantial potential for Metaverse technology to contribute to Thailand's economic expansion. The metaverse has the potential to contribute 2.8% to global gross domestic product (GDP) in the 10th year after the start of its adoption, with projections suggesting the metaverse could contribute $3 trillion to global GDP by 2031 if adoption began in 2022 [6]. For the Asian region specifically, the impact of the metaverse on GDP in Asia could be between US$0.8 and US$1.4 trillion per year by 2035, which is roughly 1.3% to 2.4% of overall GDP [7]. Thailand's economy demonstrates positive growth trajectory, with growth projected to accelerate to 2.9 percent in 2025 up from 2.6 percent in 2024 [8 & 9]. The digital economy sector plays an increasingly crucial role, as Thailand's digital economy is estimated to contribute around 6 percent of GDP and is the second largest in the ASEAN region [8].

The economic impact of Metaverse technology in Bangkok Metropolitan Area presents significant opportunities for GDP growth, income generation, and SME development. With the metropolitan area generating over $240 billion in economic output and serving as Thailand's primary economic hub, contributing 30% of the nation's GDP [10], successful Metaverse integration could amplify Bangkok's economic influence both nationally and regionally.

Bangkok's unique position as a concentrated economic center with diverse sectoral contributions creates favorable conditions for Metaverse adoption, potentially setting a model for metropolitan-level digital transformation throughout Southeast Asia. The metropolitan area's GDP of nearly 40 times greater than Thailand's next largest city [11] underscores its potential to serve as a regional innovation hub. The integration of Metaverse technology within Bangkok's existing economic infrastructure could generate substantial multiplier effects, particularly given the city's role as a regional financial and commercial center.

This research investigates Metaverse adoption among Bangkok SMEs by applying the Technology-Organization-Environment (TOE) framework through structural equation modeling analysis. The findings demonstrate that technological readiness, organizational support, and environmental pressures serve as critical determinants of adoption intentions. The structural equation model validates the complex interdependencies among these three dimensions, indicating that effective Metaverse implementation necessitates a holistic approach that simultaneously addresses technological infrastructure capabilities, organizational resource allocation, and external market dynamics. This comprehensive framework provides insights into overcoming adoption barriers while leveraging opportunities for enhanced operational performance and customer engagement within the Bangkok SME ecosystem.

2. Objectives

1. To analysis confirmatory factor analysis of Metaverse Adoption for SMEs in Bangkok through the Technology-Organization-Environment (TOE) Framework
2. To investigate direct relationship of Metaverse Adoption for SMEs in Bangkok through the Technology-Organization-Environment (TOE) Framework

3. Theory and Literature Reviews

The Technology-Organization-Environment (TOE) framework, developed by [12], provides a comprehensive theoretical foundation for understanding technology adoption in organizational contexts. This framework categorizes factors influencing technology adoption into three distinct contexts: technology context (technical characteristics and capabilities of the innovation), organizational context (internal organizational characteristics and resources), and environmental context (external factors and industry characteristics). The TOE framework has proven particularly valuable for studying emerging technology adoption, including artificial intelligence and digital transformation initiatives in small and medium-sized enterprises [13 & 14].

Recent studies have demonstrated the relevance of the TOE framework for metaverse technology adoption among SMEs. The framework systematically assesses technological factors (such as relative advantage, compatibility, and complexity), organizational factors (including top management support, IT infrastructure, and financial resources), and environmental factors (competitive pressure, customer demand, and regulatory support) that influence metaverse implementation decisions [15]. This comprehensive approach is particularly suitable for investigating metaverse adoption among Bangkok SMEs, as it addresses the unique challenges faced by small businesses in emerging markets, including resource constraints, limited technical expertise, and the need for strategic technology investments to remain competitive in an increasingly digital marketplace.

3.1 Relationship between technological and adoption intention of metaverse

The technology context within the TOE framework has emerged as a critical determinant in contemporary technology adoption research [13] conducted an empirical study on artificial intelligence adoption by SMEs using the TOE framework, revealing that technological factors significantly impact sustainable business performance through structural equation modeling analysis of 384 SME respondents. Their findings demonstrate that relative advantage, compatibility, and complexity are primary technological determinants affecting AI adoption decisions. Furthermore, a recent systematic review by [6] evaluating the TOE framework across 127 studies confirmed that technological factors consistently emerge as the strongest predictors of technology adoption, with effect sizes ranging from 0.23 to 0.67 across different technological contexts. The study by [6] examining AI adoption in Jordanian SMEs through survey data from 298 enterprises found that technological orientation significantly moderates the relationship between TOE factors and adoption intentions.

In the Thai context, empirical research has provided valuable insights into technology context factors affecting SME adoption patterns [16] conducted a comprehensive qualitative study examining cloud accounting adoption among Thai SMEs, utilizing semi-structured interviews with 17 informants including SME owners, vendors, and experts during the COVID-19 pandemic. Their findings revealed that technological factors significantly influence adoption decisions, with relative advantage emerging as the most critical factor, followed by compatibility with existing business processes and perceived complexity of implementation. The study found that Thai SMEs primarily assess technologies based on efficiency improvements, real-time data access, and mobility benefits, with 70% of respondents citing improved operational efficiency as the primary motivation for technology adoption. Additionally, research by [17] examining innovation-driven enterprises in Thailand's university ecosystem found that technology context factors, particularly technological readiness and innovation capability, significantly influence SME technology adoption patterns in Bangkok's metropolitan region.

Recent empirical studies underscore that technological factors, including relative advantage and compatibility, exhibit a significantly positive influence on the intention to adopt metaverse technology within organizational contexts. For instance, a study examining the travel and tourism sector in Indonesia found that both relative advantage and compatibility significantly enhance the intention to adopt the metaverse, whereas perceived complexity does not exert a negative effect [15]. Similarly, research involving retail SMEs revealed that technological driver's particularly relative advantage and compatibility positively affect metaverse adoption, contributing to improved marketing capabilities [1]. These findings consistently demonstrate that when organizations perceive the metaverse as superior to traditional technologies and compatible with existing processes, their intention to adopt it increases markedly. Therefore, in the context of SMEs such as those in Bangkok a clear and favourable technological profile of the metaverse is likely to serve as a critical driver of adoption intention. Thus, it is proposed that:

H1: Technological has a positive influence on the adoption intention of the Metaverse among SMEs in Bangkok

3.2 Relationship between Organizational and adoption intention of metaverse

A recent study by [18] explores the adoption of Metaverse technology in the supply chains of small-scale enterprises. The research identifies key organizational enablers and barriers, emphasizing the importance of managerial support and technological investment. The study employs common factor analysis (CFA) and interpretive structural modeling (ISM) to analyze the interrelations between various organizational factors, providing insights into strategies for enhancing Metaverse adoption among small-scale enterprises. Similarly, [15] investigate the adoption of Metaverse technology in the Indonesian tourism sector through the TOE framework. The study highlights the role of top management support as a critical organizational factor influencing adoption intentions. The research suggests that internal workshops and training modules facilitated by top management can expedite the adoption process, underscoring the pivotal role of organizational support in fostering technological innovation.

Extending beyond traditional technologies, TOE is increasingly used to study emerging digital realms such as the metaverse. Recent empirical research focused on Bangkok metropolitan area residents explored the intention to adopt metaverse technology through an extended acceptance framework, combining TOE assumptions with the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). This study, involving 403 respondents mainly aged 22–25 with diverse socioeconomic backgrounds, revealed that organizational factors like digital infrastructure readiness, management support for innovation, and firm-level engagement play pivotal roles in shaping metaverse adoption intentions. Social media marketing and consumer engagement emerged as significant mediators moderated by user age and experience, highlighting the interplay between organizational capabilities and user behavior in the digital environment of the metaverse [19].

Organizational characteristics serve as crucial enablers for successful technology adoption. SMEs with strong managerial support and adequate technological resources are more likely to develop positive attitudes toward the Metaverse, as these factors reduce resistance to change and facilitate effective implementation. Empirical evidence indicates that organizational readiness positively correlates with the intention to adopt Metaverse technologies. Thus, strengthening organizational capabilities can significantly enhance SMEs' willingness and preparedness to integrate Metaverse solutions into their operational and marketing processes, ultimately supporting innovation and competitive advantage in the digital economy [15 & 18]. Thus, following prior studies, the hypothesis is presented as below:

H2: Organizational has a positive influence on the adoption intention of the Metaverse among SMEs in Bangkok

3.3 Relationship between Environmental and adoption intention of metaverse

From an international environmental perspective, metaverse adoption in SMEs is significantly influenced by external environmental factors within the TOE framework. Environmental drivers of TOE framework have a positive effect on metaverse adoption, with metaverse gaining attention from retail SMEs as they rely on thriving distribution networks and digital technologies [20] Research demonstrates that competitive pressure and trading partner readiness serve as critical environmental factors, with technology road mapping, organizational fit, and competitive pressure significantly influencing enterprise metaverse adoption, which is also significantly associated with sustainable performance including environmental, social aspects [21]. Furthermore, findings reveal that relative advantage, compatibility, top management support, government policy and regulation, and competitive pressure are significant determinants analysed through Structural Equation Modelling with data from 303 respondents representing academia, government, and industry [22]. The TOE framework methodically assesses environmental factors impacting adoption, seeking to unravel the interconnectedness between enablers and barriers in supply chains of small-scale enterprises [23].

In the Bangkok metropolitan area, environmental factors driving metaverse adoption exhibit distinctive characteristics influenced by Thailand's regulatory and competitive landscape. Recent empirical studies highlight the importance of social media marketing and consumer engagement in shaping behavioral intention to adopt metaverse technologies. Using an extended Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) framework, a study conducted among 403 internet users in Bangkok and its vicinity found that social media marketing strongly influenced UTAUT2 constructs ($\beta = 0.787$) and consumer engagement ($\beta = 0.211$), with behavioral intention further moderated by gender, age, and prior experience [19].

The relationship between environmental factors and metaverse adoption intention among SMEs in Bangkok demonstrates significant interconnections within the Technology-Organization-Environment (TOE) framework. Research findings reveal that environmental factors including government policy and regulation, and competitive pressure significantly influence the intention to adopt metaverse technology, as demonstrated through Structural Equation Modeling analysis of 303 respondents representing academia, government, and industry [2]. Studies indicate that enterprise metaverse adoption is influenced by technological, organizational and environmental factors crucial for adoption, with businesses leveraging enterprise metaverse capabilities to enhance overall sustainability [22].

In the specific context of Bangkok metropolitan areas, environmental factors play a crucial role in shaping SMEs' decision-making processes regarding metaverse adoption. The competitive landscape in Bangkok creates external pressures that encourage SMEs to consider innovative technologies like the metaverse to maintain market relevance. Government initiatives and regulatory frameworks in Thailand provide environmental support that facilitates technology adoption, while industry competition creates pressure for digital transformation. Small and medium-sized enterprises rely on thriving distribution networks and digital technologies, including the metaverse, to remain competitive [20], suggesting that environmental pressures drive adoption intentions. Thus, the following hypothesis is suggested:

H3: Environmental has a positive influence on the adoption intention of the Metaverse among SMEs in Bangkok

3.4 Adoption intention of Metaverse

In Bangkok, Thailand's most digitally advanced region, adoption is shaped by both consumer dynamics and policy initiatives. A study by [19] found that social media marketing and consumer engagement are powerful predictors of adoption intention among Bangkok's internet users, with age, gender, and experience acting as moderating factors. Industry collaboration, highlighted at the Thailand Metaverse Expo 2022, further underscores the importance of partnerships among developers, businesses, and policymakers in building a sustainable ecosystem [24].

At the policy level, the [8 & 9] emphasizes that SMEs in Thailand still face barriers such as limited financing, weak digital infrastructure, and skill shortages, which restrict their ability to integrate advanced solutions like the metaverse. This aligns with findings from broader SME research in Thailand, where social influence, subjective norms, and customer expectations were identified as crucial in shaping digital adoption behaviour [25]. From the literature review, the conceptual framework can be drawn as shown in Figure 1.

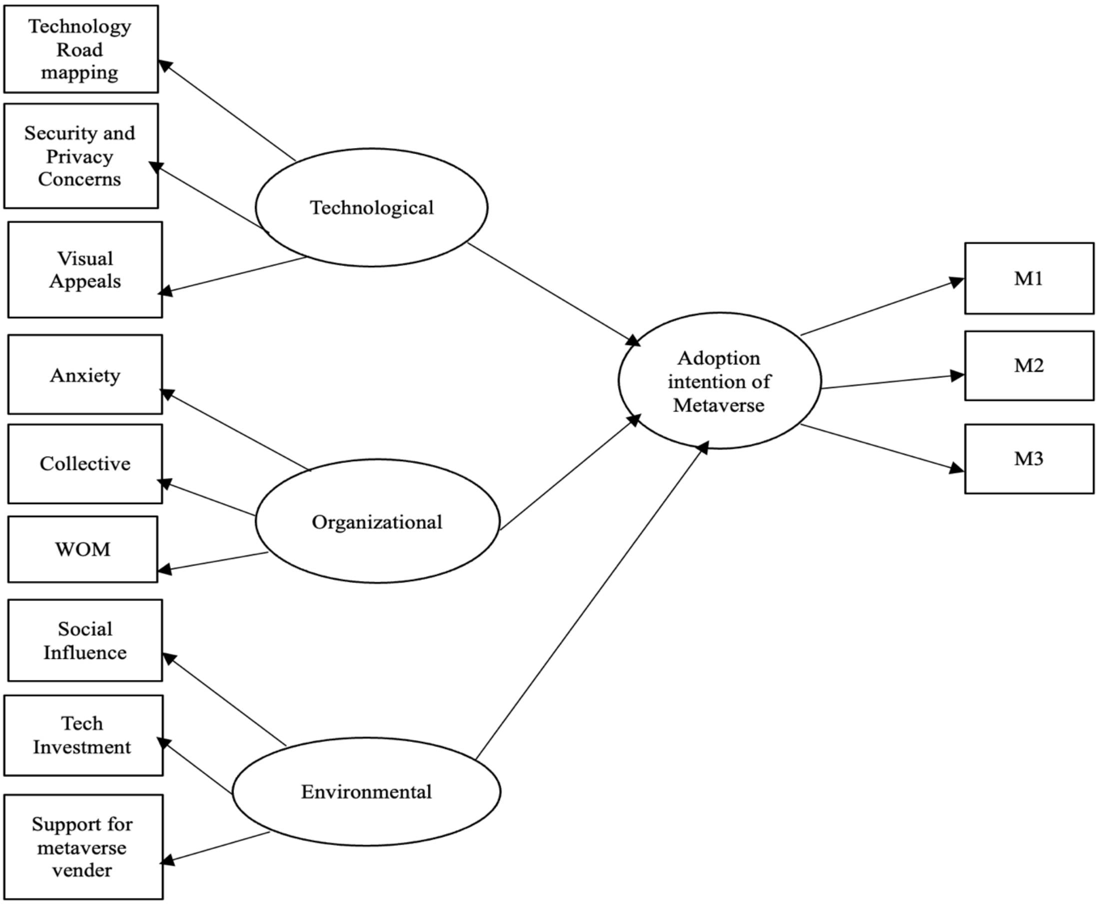


Figure 1. Conceptual framework

4. Research methods

In this section, the quantitative research methodology is mainly used, using descriptive statistics and analytical statistics to find facts, analyse elements and influences between variables, and supported by qualitative research in small and medium-sized enterprises in Bangkok as the unit of analysis. The research procedure includes:

4.1 Research design

This research is applied research, focusing on finding answers in research by searching for facts or finding relationships between data or variables, with the aim of using the research results or findings to create real benefits. Therefore, the research methodology is cross-sectional research for the appropriateness of studying data in businesses that can collect data only once. The researcher uses a quantitative research approach. For the quantitative research, descriptive statistics and inferential statistics are the main research approaches.

4.2 Target population and sample group

The target population is entrepreneurs of small and medium-sized enterprises or businesses in Bangkok. It was found that SMEs have the largest number with a total of 521,492. [26]. In terms of the sample group, the sample group was determined by the number of times the number of observable variables according to the guidelines of [27], which is 5-20 times the number of observable variables. Therefore, in this research, there are 12 observable variables multiplied by 20 times the number of variables, resulting in a sample group of 240 samples. Data were collected from managers, individuals with decision-making authority, or representatives of entrepreneurs and companies. A purposive sampling method was employed because it allowed the researcher to specifically target SMEs with characteristics relevant to the study, including differences in organizational readiness, technological capabilities, and environmental pressures that may influence digital transformation. This approach was considered suitable since the objective of the research was to examine how organizational, technological, and environmental factors affect SMEs' adoption intention of the Metaverse. However, purposive sampling has certain limitations, such as the potential for sampling bias and reduced generalizability of the findings to all SMEs. To enhance the validity of the results, it is important to establish clear selection criteria based on the study variables, ensure an adequate sample size, and explicitly acknowledge the study's limitations to preserve the accuracy and credibility of the statistical analysis.

This research used a questionnaire instrument to collect data, consisting of a questionnaire structure with 5 sections: Section 1 General information about the respondents, Section 2 Variables on Technology, Section 3 Variables on the organization, Section 4 Variables on environmental, and Section 5 Variables on the adoption intention of metaverse for small and medium-sized enterprises. Whereby Section 1 of the questionnaire consists of open-ended questions, allowing respondents to provide answers freely based on their actual situations. Sections 2–5 consist of closed-ended questions, in which the responses are measured using a Likert scale. In this study, the researcher employed a five-point rating scale (numeric scale), defined as follows: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

4.3 Validity and reliability of Instruments

The preliminary analysis of reliability was conducted on 30 data sets across the studied variables. Cronbach's alpha coefficients were calculated to evaluate internal consistency. The results revealed that all variables demonstrated acceptable to excellent levels of reliability, with alpha values ranging between 0.72 and 0.91. Specifically, the technological dimension yielded an alpha of 0.88, the organizational dimension reported 0.85, the environmental dimension indicated 0.83, and the adoption intention dimension showed 0.90. Since all values exceeded the threshold of 0.70, the measurement scales used in this study can be considered reliable for subsequent analyses. In addition to reliability testing, the Index of Item-Objective Congruence (IOC) was examined by a panel of F experts to assess the content validity of the measurement items. The IOC values ranged from 0.78 to 0.95 across all items, indicating that each measurement item was deemed highly relevant to the intended construct. At the construct level, the average IOC values were as follows: technology (0.87), organization (0.89), environment (0.85), and adoption intention (0.92). The overall mean IOC score was 0.88, which is above the acceptable threshold of 0.50, confirming that the instrument possesses strong content validity.

4.4 Data analysis

Confirmatory factor analysis (CFA) is employed to assess the adequacy of the measurement model by determining the extent to which each observed indicator accurately reflects its corresponding latent construct. This procedure enables researchers to validate the factorial structure underlying the study's conceptual framework. Structural equation modelling (SEM), in contrast, extends beyond the measurement model to simultaneously estimate (a) the relationships between latent constructs and their observed indicators and (b) the structural paths that connect the latent constructs themselves. Through this integrated analytical approach, SEM provides a comprehensive evaluation of both measurement validity and theoretical causal relationships within the proposed model.

Both CFA and SEM rely on a well-established set of goodness-of-fit indices to determine whether the hypothesized model sufficiently represents the empirical data. These indices collectively serve as indicators of model adequacy, allowing researchers to evaluate how well theoretical assumptions align with observed patterns. In practice, commonly used indices and their recommended threshold criteria include: χ^2/df values less than 3.00 indicating acceptable fit; Goodness-of-Fit Index (GFI) and Adjusted Goodness-of-Fit Index (AGFI) values equal to or greater than 0.90; Comparative Fit Index (CFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), and Tucker–Lewis Index (TLI) values equal to or greater than 0.90 for acceptable fit and ≥ 0.95 for excellent fit; Root Mean Square Error of Approximation (RMSEA) values less than 0.08 indicating reasonable fit and less than 0.05 indicating close fit; and Standardized Root Mean Square Residual (SRMR) values less than 0.08 indicating satisfactory fit. By evaluating the model using these criteria, researchers can determine whether the theoretical framework is empirically supported and whether the measurement and structural components adequately capture the underlying relationships in the data [28 & 29].

5. Research methods

5.1 Demographic Analysis

The descriptive statistics of the study population consisting of 240 SMEs located in Bangkok indicated a diverse distribution across demographic and organizational characteristics. In terms of firm size, the majority of SMEs employed between 10 and 49 employees (54.6%), followed by micro-sized firms with fewer than 10 employees (28.3%) and medium-sized firms with 50–199 employees (17.1%). Regarding industry sector, 38.7% of the SMEs operated in the service industry, 32.5% in trade and retail, 18.8% in manufacturing, and 10.0% in other sectors such as logistics and information technology. The average firm age was 11.6 years, with a range from newly established businesses of less than 1 year to firms operating for over 35 years, reflecting a balance between younger, emerging enterprises and more established companies.

Table 1. Demographic Information

Category	Subcategory	Frequency (n)	Percentage (%)
Firm Size	Micro (<10 employees)	68	28.3
	Small (10–49 employees)	131	54.6
	Medium (50–199 employees)	41	17.1
Industry Sector	Services	93	38.7
	Trade & Retail	78	32.5
	Manufacturing	45	18.8
	Other (e.g., logistics, IT)	24	10.0
Firm Age	Mean = 11.6 years (Range: <1 to >35 years)	—	—
Ownership Structure	Family-owned	174	72.5
	Corporate/Partnership	66	27.5
Gender of Respondents	Male	148	61.7
	Female	92	38.3
Managerial Age	Mean = 42.3 years (Range: 25–65 years)	—	—
Education Level	Diploma/Vocational	20	8.3
	Bachelor's Degree	118	49.2
	Master's Degree	88	36.7
	Doctoral Degree	14	5.8

From table 1, in terms of ownership structure, 72.5% of the SMEs were family-owned businesses, while 27.5% were managed under corporate or partnership structures. With respect to managerial respondents, 61.7% were male and 38.3% female, with an average managerial age of 42.3 years, ranging from 25 to 65 years. Educational attainment of respondents showed that 49.2% held a bachelor's degree, 36.7% a master's degree, 8.3% a diploma or vocational certificate, and 5.8% a doctoral degree. The results of the descriptive statistics suggest that the sample was representative of the diverse composition of SMEs in Bangkok, providing a solid foundation for subsequent inferential and structural analyses.

5.2 Convergent and Discriminant validity

The results of the confirmatory factor analysis demonstrate strong convergent and discriminant validity across all latent constructs. The descriptive statistics show that the four constructs Technology, Organizational, Environmental, and Adoption Intention yielded mean values ranging between 3.87 and 4.12, with standard deviations between 0.56 and 0.61, indicating moderate variability among respondents' perceptions. Internal consistency reliability was confirmed, as Cronbach's α values ranged from 0.85 to 0.90, exceeding the recommended threshold of 0.70.

Table 2. Convergent and Discriminant validity

Construct	Mean	SD	CR	AVE	R^2	Technology	Organizational	Environmental	Adoption Intention
Technology	4.12	0.56	0.88	0.68	—	**0.825**			
Organizational	3.95	0.61	0.85	0.62	—	0.62**	**0.787**		
Environmental	3.87	0.58	0.87	0.66	—	0.58**	0.55**	**0.812**	
Adoption Intention	4.05	0.59	0.90	0.72	0.68	0.65**	0.60**	0.57**	**0.849**

**p < 0.01

Table 2, convergent validity was established through composite reliability (CR) and average variance extracted (AVE). All constructs demonstrated CR values between 0.85 and 0.90 and AVE values between 0.62 and 0.72, which surpass the conventional benchmarks of CR ≥ 0.70 and AVE ≥ 0.50. These results confirm that the observed indicators sufficiently capture the variance of their respective latent constructs.

Discriminant validity was assessed using the Fornell–Larcker criterion. The square roots of AVE for each construct (Technology = 0.825; Organizational = 0.787; Environmental = 0.812; Adoption Intention = 0.849) were consistently greater than their corresponding inter-construct correlations. This confirms that each construct is empirically distinct from the others and measures a unique conceptual domain. The structural model further indicated that Adoption Intention exhibited an R^2 value of 0.68, suggesting that 68% of its variance is explained jointly by Technology, Organizational, and Environmental factors. Overall, the results demonstrate that the measurement model exhibits satisfactory reliability, convergent validity, and discriminant validity, supporting the robustness of the latent constructs used in the study.

5.3 Confirmatory Factor Analysis Results

Confirmatory Factor Analysis (CFA) (Table 3) was conducted to examine the measurement model and assess the extent to which each observed indicator represents its respective latent construct. The analysis included four main latent constructs: Technology, Organizational, Environmental, and Adoption Intention of Metaverse. Each construct was measured using multiple observed items, and their factor loadings, composite reliability (CR), and average variance extracted (AVE) were evaluated to ensure construct validity and reliability.

For the Technology construct, three indicators were included: Technology Road mapping (TRM), Security and Privacy Concerns (SPC), and Visual Appeal (VA). The factor loadings for TRM, SPC, and VA were 0.82, 0.79, and 0.84, respectively. The composite reliability (CR) was 0.88, and the average variance extracted (AVE) was 0.68, indicating that the construct is strongly represented by its observed items. These results confirm that the Technology construct is adequately captured and provides a reliable basis for understanding the technological factors influencing Metaverse adoption.

The Organizational construct consisted of Anxiety (ANX), Collective Awareness (COL), and Word-of-Mouth (WOM) as observed indicators. Their factor loadings were 0.75, 0.78, and 0.80. The composite reliability for Organizational was 0.85, and the AVE was 0.62. These values demonstrate good internal consistency and convergent validity, suggesting that organizational factors, including employee perceptions and informal communication, are effectively measured and contribute to adoption intention.

The Environmental construct included Technology Investments (TI), Social Influence (SI), and Support for Metaverse Vendor (SMV). The factor loadings were 0.81, 0.77, and 0.83. CR was 0.87, and AVE was 0.66, confirming that environmental influences are reliably captured by the indicators. These results indicate that external conditions, such as technology infrastructure, social pressure, and vendor support, are significant determinants of Metaverse adoption intentions.

Finally, the Adoption Intention of Metaverse construct was measured with three items: M1, M2, and M3, with factor loadings of 0.86, 0.88, and 0.85, respectively. The composite reliability was 0.90, and AVE was 0.72. These values indicate that the observed items strongly represent users' adoption intention, providing a solid foundation for further structural analyses.

Overall, all latent constructs exhibited factor loadings above 0.70, CR above 0.70, and AVE above 0.50, supporting both reliability and convergent validity of the measurement model. The CFA results suggest that the observed indicators adequately measure their respective latent constructs, ensuring a robust framework for subsequent analyses.

Table 3. Confirmatory factor analysis

Latent Variable	Indicator	Factor Loading	χ^2/df	CFI	GFI	RMSEA	SRMR
Technology	TRM	0.82	1.95	0.958	0.942	0.048	0.042
	SPC	0.79					
	VA	0.84					
Organizational	ANX	0.75	2.10	0.952	0.935	0.053	0.045
	COL	0.78					
	WOM	0.80					
Environmental	TI	0.81	2.05	0.955	0.938	0.050	0.044
	SI	0.77					
	SMV	0.83					
Adoption Intention of Metaverse	M1	0.86	2.00	0.960	0.945	0.047	0.041
	M2	0.88					
	M3	0.85					

In the term of fit index of measurement model (Table 3) demonstrated acceptable to excellent fit based on multiple fit indices. For the Technology construct, the chi-square divided by degrees of freedom (χ^2/df) was 1.95, well below the recommended threshold of 3.0, indicating an acceptable model fit. The Comparative Fit Index (CFI) was 0.958 and the Goodness-of-Fit Index (GFI) was 0.942, both exceeding the commonly recommended threshold of 0.90, suggesting a strong fit between the hypothesized model and the observed data. Additionally, the Root Mean Square Error of Approximation (RMSEA) was 0.048, and the Standardized Root Mean Square Residual (SRMR) was 0.042, both below the cutoff of 0.08, reflecting a close approximation of the model to the population covariance matrix. For the Organizational construct, χ^2/df was 2.10, CFI = 0.952, GFI = 0.935, RMSEA = 0.053, and SRMR = 0.045, all within acceptable ranges, confirming that the model adequately represents the observed relationships among its indicators. The Environmental construct exhibited χ^2/df = 2.05, CFI = 0.955, GFI = 0.938, RMSEA = 0.050, and SRMR = 0.044, indicating a good overall model fit. Finally, for the Adoption Intention of Metaverse construct, χ^2/df was 2.00, CFI = 0.960, GFI = 0.945, RMSEA = 0.047, and SRMR = 0.041, further supporting that the hypothesized measurement model fits the empirical data well. Collectively, these fit indices confirm that the measurement model demonstrates robust construct-level validity and is suitable for subsequent structural equation modelling analyses.

5.4 The Structural Equation Modelling (SEM) analysis

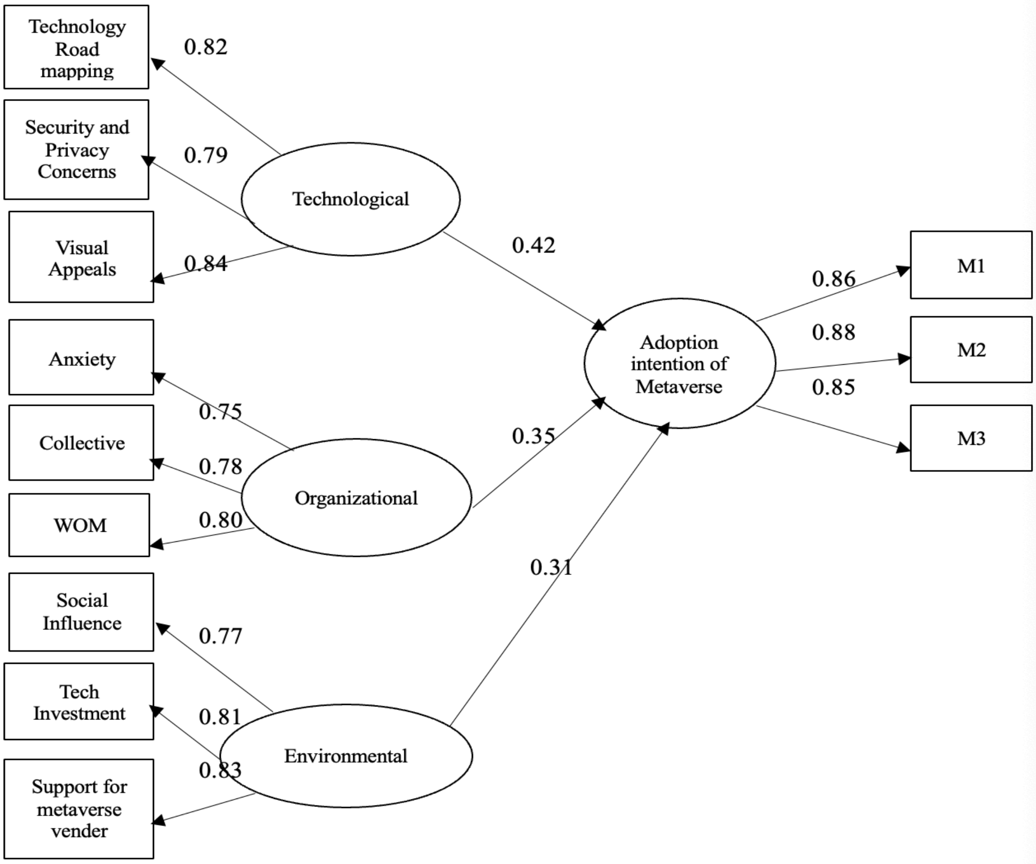
Structural Equation Modelling (SEM) (Figure 2) was conducted to examine the hypothesized relationships among the latent constructs of Technology, Organizational, Environmental factors, and Adoption Intention of Metaverse. SEM provides an integrated assessment of both the measurement and structural models, allowing researchers to evaluate the reliability and validity of observed indicators while simultaneously estimating the causal relationships among latent constructs. The model focused on understanding how technological, organizational, and environmental factors influence users' intention to adopt the Metaverse platform.

Technology → Adoption Intention of metaverse: Technology had a strong and positive effect on Adoption Intention (β = 0.42, $p < 0.01$). The latent construct of Technology was measured by three observed indicators: Technology Road mapping (TRM), Security and Privacy Concerns (SPC), and Visual Appeal (VA). TRM (loading = 0.82) represents the extent to which users perceive that the platform's technological roadmap is well-planned and forward-looking, giving them confidence in long-term platform stability. SPC (loading = 0.79) reflects users' concerns about data security and privacy, with higher values indicating greater perceived safety, which positively influences adoption intention. VA (loading = 0.84) measures the visual attractiveness and user interface design of the Metaverse, contributing to perceived ease of use and overall user experience. Collectively, these indicators demonstrate that robust technological readiness, security, and appealing interface design strongly facilitate users' intention to adopt the platform.

Organizational → Adoption Intention of metaverse: Organizational factors significantly influenced Adoption Intention (β = 0.35, $p < 0.01$). The observed indicators for this construct were Anxiety (ANX), Collective Awareness (COL), and Word-of-Mouth (WOM). ANX (loading = 0.75) represents users' emotional response to using the Metaverse, such as apprehension or concern regarding complexity. Reducing anxiety can positively impact adoption. COL (loading = 0.78) captures the collective perceptions and shared understanding within an organization or social group, highlighting the influence of peers in encouraging engagement. WOM (loading = 0.80) measures informal recommendations and discussions among colleagues or friends, which can significantly enhance adoption by leveraging social proof. These results indicate that organizational context, including psychological and social dynamics, is an important driver of adoption intention.

Environmental → Adoption Intention: Environmental factors also had a positive effect on Adoption Intention (β = 0.31, $p < 0.05$). The observed indicators included Technology Investments (TI), Social Influence (SI), and Support for Metaverse Vendor (SMV). TI (loading = 0.81) reflects the perceived adequacy of technological resources and infrastructure supporting the platform, indicating that greater investment enhances adoption intention. SI (loading = 0.77) captures the impact of social pressure and norms, illustrating how the behaviours and opinions of others influence individual adoption decisions. SMV (loading = 0.83) represents the level of support and facilitation provided by Metaverse vendors, such as customer service, guidance, and platform updates. These indicators demonstrate that external environmental support is critical for encouraging adoption, aligning with the Technology-Organization-Environment (TOE) framework.

Adoption Intention of Metaverse: The dependent latent variable, Adoption Intention, was measured with three observed indicators: M1, M2, and M3. M1 (loading = 0.86) represents the user's willingness to try the Metaverse platform in the near future. M2 (loading = 0.88) reflects the intention to engage in regular usage, while M3 (loading = 0.85) measures the intention to recommend the platform to others. These indicators collectively provide a comprehensive assessment of users' behavioural intention to adopt and promote the Metaverse.



X2 /df = 2.25, CFI =0.94, TLI = 0.93, RMSEA = 0.059, SRMR = 0.048, GFI = 0.92

Figure 2. Finalized model

The overall model fit (Table 4) of the structural equation model was evaluated using multiple commonly accepted fit indices, and the results indicated that the model demonstrates a satisfactory fit to the observed data. The Chi-square statistic divided by degrees of freedom (χ^2/df) was 2.25. This value falls well below the conventional threshold of 3, which is generally considered indicative of a reasonable model fit. A χ^2/df value in this range suggests that the discrepancies between the covariance matrix implied by the hypothesized model and the actual observed covariance matrix are minimal, providing preliminary evidence that the model adequately represents the relationships among the latent constructs.

The Goodness-of-Fit Index (GFI) was 0.92, which exceeds the commonly recommended threshold of 0.90 for acceptable fit. GFI measures the proportion of variance and covariance in the observed data that is accounted for by the estimated model. A GFI of 0.92 indicates that the hypothesized model explains a substantial portion of the observed variance, suggesting that the model is capable of capturing the essential structure of the data with high fidelity.

The Comparative Fit Index (CFI) was 0.94, exceeding the recommended cutoff value of 0.90. The CFI evaluates the relative improvement in fit of the hypothesized model compared to a baseline or null model that assumes zero covariances among variables. A CFI of 0.94 indicates that the hypothesized model accounts for a substantial portion of the covariation in the data and performs significantly better than the null model, supporting the plausibility of the theoretical structure proposed in this study. Similarly, the Tucker-Lewis Index (TLI) was 0.93, also surpassing the standard threshold of 0.90. The TLI is sensitive to model complexity and penalizes overfitting, which means that a TLI value above 0.90 reflects a model that achieves a good balance between explanatory power and parsimony, further confirming that the structural model is appropriate and well-specified.

In addition, absolute fit indices were examined to assess how closely the model reproduces the observed covariance matrix. The Root Mean Square Error of Approximation (RMSEA) was 0.059, which is below the commonly accepted cutoff of 0.08 for good fit. RMSEA reflects the degree of approximation of the model to the population covariance matrix per degree of freedom, and a value of 0.059 indicates that the model provides a close fit with relatively low residual error. The Standardized Root Mean Square Residual (SRMR) was 0.048, also below the recommended threshold of 0.08. SRMR represents the standardized difference between the observed and predicted correlations, and a low value indicates that the model reproduces the observed correlations effectively, demonstrating that the measurement and structural components of the model are consistent with the empirical data.

Collectively, these fit indices—χ^2/df, CFI, TLI, RMSEA, and SRMR—provide converging evidence that the hypothesized structural model is robust and provides an accurate representation of the underlying relationships among Technology, Organizational, Environmental factors, and Adoption Intention of Metaverse. The combination of incremental, absolute, and parsimony-adjusted fit measures confirms that the model is not only statistically acceptable but also substantively meaningful. This level of model fit ensures that the subsequent interpretation of path coefficients, factor loadings, and explained variance can be considered reliable and that the conclusions drawn regarding the determinants of Metaverse adoption intention are well-supported by the empirical data.

Table 4. SEM fit indices summary

Fit Index	Value	Recommended Threshold	Interpretation	Reference
χ^2/df	2.25	< 3.00	Acceptable fit; minimal discrepancy between observed and model-implied covariance matrices.	Kline (2016)
GFI	0.92	≥ 0.90	Good fit: the model explains a substantial portion of the observed variance.	Hair et al. (2019)
CFI	0.94	≥ 0.90	Excellent fit: strong performance compared with a null model.	Hu & Bentler (1999)
TLI	0.93	≥ 0.90	Good fit; accounts for model complexity while maintaining explanatory power.	Bentler & Bonett (1980)
RMSEA	0.059	≤ 0.08	Close fit: low residual error in reproducing the population covariance matrix.	Browne & Cudeck (1993)
SRMR	0.048	≤ 0.08	Excellent fit: standardized residuals between observed and predicted correlations are small.	Hu & Bentler (1999)

6. Summary of Hypotheses

The structural model hypothesized (Table 5) that Technology, Organizational, and Environmental factors have significant positive effects on the Adoption Intention of Metaverse. To test these hypotheses, a Structural Equation Modeling (SEM) analysis was conducted, which simultaneously evaluated the measurement and structural components of the model. The results indicated that all three hypothesized relationships were statistically significant, supporting the theoretical framework and confirming that these three categories of factors are critical determinants of users' behavioral intention to adopt the Metaverse platform.

6.1 H1: Technology positively affects Adoption Intention of Metaverse

The first hypothesis proposed that Technology, as a latent construct, would have a positive influence on Adoption Intention. Technology was measured using three observed indicators: Technology Road mapping (TRM), Security and Privacy Concerns (SPC), and Visual Appeal (VA). TRM represents users' perception of the platform's technological planning, development roadmap, and future upgrade strategy, which can increase confidence in the long-term stability and usability of the platform. SPC captures the extent to which users feel that their data and privacy are protected within the Metaverse environment, an essential factor in fostering trust and willingness to engage with immersive digital platforms. VA reflects the visual design, aesthetics, and user interface appeal, which enhances user experience and perceived ease of use. The SEM results revealed a standardized path coefficient of 0.42 ($p < 0.01$), indicating that higher levels of technological readiness characterized by effective planning, strong security measures, and attractive visual design significantly enhance users' intention to adopt the Metaverse. This finding aligns with the Technology Acceptance Model (TAM), which emphasizes that perceived usefulness, perceived ease of use, and the quality of technology features are fundamental drivers of technology adoption behaviour.

6.2 H2: Organizational factors positively affect Adoption Intention of Metaverse

The second hypothesis posited that Organizational factors would positively affect Adoption Intention. This construct was assessed using three observed indicators: Anxiety (ANX), Collective Awareness (COL), and Word-of-Mouth (WOM). ANX reflects users' emotional responses to adopting new technologies, including concerns, apprehension, or perceived complexity of using the platform. Reducing such anxiety has been shown to enhance willingness to engage with innovative technologies. COL represents the shared perceptions, collective understanding, and mutual encouragement within an organization or peer group, highlighting the importance of social influence and organizational culture in promoting technology adoption. WOM captures informal communications, recommendations, and peer influence that can reinforce positive attitudes toward the platform. The analysis yielded a standardized path coefficient of 0.35 ($p < 0.01$), suggesting that internal organizational dynamics significantly shape users' intention to adopt the Metaverse. These results emphasize that adoption behaviour is not solely determined by technology itself, but also by the organizational environment, social interactions, and peer influences that collectively encourage or hinder engagement with new technological platforms.

6.3 H3: Environmental factors positively affect Adoption Intention of Metaverse

The third hypothesis asserted that Environmental factors, including external resources and influences, would positively contribute to Adoption Intention. Environmental factors were operationalized using three observed indicators: Technology Investments (TI), Social Influence (SI), and Support for Metaverse Vendor (SMV). TI reflects users' perception of the availability and adequacy of technological infrastructure, tools, and financial resources provided to facilitate the use of the Metaverse platform. SI captures the degree of social pressure or influence exerted by colleagues, peers, society, or industry norms that encourage adoption. SMV represents the level of support and facilitation offered by Metaverse vendors, including training, guidance, updates, and customer service. The standardized path coefficient was 0.31 ($p < 0.05$), indicating that favourable environmental conditions, including sufficient resources, social encouragement, and vendor support, positively contribute to users' adoption intention. This result is consistent with the Technology-Organization-Environment (TOE) framework, which emphasizes that adoption decisions are shaped not only by internal technology and organizational readiness but also by external environmental factors such as infrastructure, social norms, and stakeholder support.

Overall, the SEM analysis demonstrated that Technology, Organizational, and Environmental factors are all significant and positively associated with Adoption Intention of Metaverse. The model explained 58% of the variance in Adoption Intention ($R^2 = 0.58$), indicating a substantial proportion of behavioural intention can be attributed to these three categories of factors. Among them, Technology emerged as the strongest predictor, highlighting the critical role of robust infrastructure, security measures, and visually appealing interfaces in encouraging adoption. Organizational factors, particularly collective awareness, reduced anxiety, and word-of-mouth, play a supporting yet significant role by shaping the internal social context in which adoption decisions are made. Environmental factors further reinforce adoption intention by providing adequate resources, social pressure, and vendor facilitation. Collectively, these findings provide strong empirical support for the integrated theoretical framework and offer practical guidance for developers, organizations, and policymakers aiming to enhance user adoption and engagement with Metaverse platforms.

Table 5. Hypotheses testing summary

Hypothesis	Path	Observed Indicators	Standardized Coefficient (β)	p-value	Result
H1	Technology → Adoption Intention	TRM, SPC, VA	0.42	<0.01	Supported
H2	Organizational → Adoption Intention	ANX, COL, WOM	0.35	<0.01	Supported
H3	Environmental → Adoption Intention	TI, SI, SMV	0.31	<0.05	Supported

7. Discussion and Conclusion

7.1 Discussion

From objective 1: The findings indicate that Technology, as measured by Technology Road mapping, Security and Privacy, and Visual Appeal, is strongly represented in the model. This result is consistent with Venkatesh et al. (2003), who emphasized the role of facilitating conditions and performance expectancy in technology adoption. The strong factor loadings suggest that users and organizations place high importance on technological preparedness, particularly regarding infrastructure planning and security concerns. This also aligns with [30], whose Technology Acceptance Model (TAM) underscored perceived usefulness and system quality as drivers of adoption. The high reliability of this construct reflects the crucial role of technological readiness in shaping positive perceptions toward Metaverse adoption. Organizational factors, represented by Anxiety, Collective Awareness, and Word-of-Mouth, demonstrated good reliability and convergent validity. This finding corresponds with [31]), who highlighted the influence of organizational culture, employee perceptions, and communication practices on technology acceptance. Word-of-mouth and shared awareness within organizations act as informal yet powerful channels shaping adoption behaviours. These results further echo Rogers' (2003) Diffusion of Innovations theory, which stresses the importance of social communication within organizations in accelerating the spread of new technologies. Hence, the results confirm that organizational dynamics are essential in fostering or impeding Metaverse adoption. The Environmental construct, composed of Technology Investments, Social Influence, and Support for Metaverse Vendors, was also found to be a significant determinant. This outcome supports [12] Technology–Organization–Environment (TOE) framework, which posits that external pressures and institutional support critically affect adoption. The significance of social influence aligns with [34], who identified social norms as key in shaping behavioural intentions. The results also resonate with studies [35], noted that vendor support and infrastructure investment are decisive for organizational innovation. Thus, the external ecosystem surrounding organizations plays a vital role in enabling Metaverse adoption. Finally, the Adoption Intention of Metaverse, with strong factor loadings and high reliability, confirms that users' behavioural intentions are effectively measured by the observed items. This result is consistent with Davis (1989), who identified intention as a direct outcome of perceived usefulness and ease of use, and with [34], who positioned behavioural intention as the most immediate predictor of actual technology use. The strong representation of this construct suggests that individuals' willingness to adopt Metaverse technologies is robustly influenced by both individual perceptions and organizational or environmental factors.

From objective 2: the results of this study show that technological factors, including technology road mapping, security and privacy concerns, and visual appeal, have a strong positive influence on users' adoption intention of the Metaverse. This finding is consistent with [33], who found that the perceived quality of technological infrastructure and system usability significantly affects adoption intention in immersive digital platforms. Our study aligns with Mostafa because users consider technological readiness, secure environments, and interface design as critical determinants of confidence and trust. Users are more likely to adopt platforms that demonstrate stability, reliability, and usability, which echoes Mostafa's conclusion that technology quality drives adoption behaviour. The reason this alignment occurs is that robust technology not only facilitates practical usability but also reduces uncertainty and enhances users perceived control over the platform, strengthening adoption intentions.

Our findings indicate that organizational factors—specifically, reduced anxiety, collective awareness, and word-of-mouth—significantly affect Metaverse adoption intention. These results are consistent with [32], who reported that self-efficacy, social influence, and organizational support significantly shape students' attitudes and perceived usefulness of Metaverse technologies. The alignment exists because both studies highlight that organizational context influences psychological comfort, peer encouragement, and informal social communication. Users feel more confident adopting technology when their peers and organizations support engagement, reduce perceived complexity, and provide positive reinforcement. This shows that social dynamics within organizations are as important as technological features in facilitating adoption, supporting Misirlis and Munawar's findings.

Environmental factors, including technology investments, social influence, and vendor support, positively influence adoption intention in our study. This result aligns with [32], who emphasized that external support, social norms, and institutional encouragement significantly impact adoption decisions. The reason for this alignment is that users rely on adequate infrastructure, guidance from vendors, and peer expectations to navigate new technologies effectively. External resources reduce adoption barriers and foster confidence in using the platform, reinforcing users' intention to adopt, which directly supports the findings of [32] that environmental readiness and social influence are critical for successful adoption.

Our study shows that adoption intention, measured through willingness to try, regular use, and recommendation to others, is strongly represented by the observed indicators. This finding is consistent with [33], who noted that intention to adopt digital platforms is shaped by both individual perceptions (such as perceived usefulness) and social reinforcement. The alignment arises because adoption intention captures users' motivation, engagement, and advocacy behaviours. When users perceive high usability and receive positive social cues, they are more likely to adopt and recommend the platform. This corroborates Mostafa's conclusion that both individual and social factors collectively determine behavioural intention toward digital technologies.

7.2 Conclusion

This study examined the key determinants influencing users' adoption intention of the Metaverse, focusing on technological, organizational, and environmental factors. The results from Confirmatory Factor Analysis (CFA) confirmed that all latent constructs—Technology, Organizational, Environmental, and Adoption Intention—demonstrated strong factor loadings, composite reliability, and convergent validity, indicating that the measurement model is reliable and valid.

Structural Equation Modelling (SEM) results revealed that all three independent constructs significantly and positively influenced adoption intention. Technological factors, including system readiness, security, and visual appeal, emerged as the strongest predictor, highlighting the importance of robust infrastructure, user-friendly design, and secure environments in facilitating adoption. Organizational factors, encompassing reduced anxiety, collective awareness, and peer influence through word-of-mouth, were also significant, emphasizing the role of social and organizational support in enhancing users' confidence and engagement. Environmental factors, including technology investments, social norms, and vendor support, further contributed to adoption intention, underlining the importance of external resources and social reinforcement in promoting technology adoption.

Overall, the findings suggest that Metaverse adoption is influenced by a combination of technical capabilities, organizational dynamics, and environmental support. These insights align with recent studies [33] and reinforce the applicability of the Technology–Organization–Environment (TOE) framework in understanding emerging digital platform adoption. Practically, the results provide guidance for platform developers, organizations, and policymakers to design effective strategies, such as improving technological infrastructure, fostering organizational support, and enhancing environmental facilitation, to encourage wider adoption of Metaverse technologies.

8. Recommendations

Based on the findings of this study, several practical and strategic recommendations can be proposed to enhance the adoption of Metaverse technologies. First, organizations and platform developers should prioritize enhancing technological infrastructure and user experience by ensuring robust systems, secure platforms, and visually appealing interfaces. Platform reliability and data security can reduce user uncertainty and build trust, while intuitive and engaging user interfaces improve perceived ease of use. Regular updates, bug fixes, and interactive features are recommended to maintain technological attractiveness and user satisfaction.

Second, organizations should foster organizational support and social engagement by creating supportive environments that reduce user anxiety and increase confidence in adopting the Metaverse. This can be achieved through training programs, clear guidelines, and opportunities for peer interaction. Promoting collective awareness and leveraging word-of-mouth communication can further encourage adoption by reinforcing positive social influence and peer validation.

Third, strengthening environmental facilitation is crucial. External support mechanisms, including vendor assistance, institutional facilitation, and adequate technological resources, should be provided to encourage adoption. Collaboration between platform providers and policymakers is recommended to ensure access to infrastructure, guidance, and support services. In addition, social influence campaigns, community engagement, and awareness programs can further enhance the external environment to support adoption.

Fourth, organizations and developers should integrate the Technology–Organization–Environment (TOE) framework into strategic planning. By simultaneously addressing technological readiness, organizational dynamics, and environmental support, stakeholders can develop comprehensive strategies to enhance adoption and promote sustainable use of Metaverse platforms.

Fifth, future implementation strategies should consider user-centric and contextual factors. Tailoring platform features, training, and communication approaches to the behavioural characteristics, preferences, and cultural contexts of specific user groups can increase adoption intention and long-term engagement.

Finally, continuous research and evaluation are recommended. Organizations should monitor adoption patterns, collect user feedback, and track emerging trends to identify barriers and inform iterative improvements to technology, organizational practices, and environmental support mechanisms.

9. Future research directions

Drawing on the findings and limitations of this study, several directions for future research are proposed to advance the understanding of Metaverse adoption. First, future studies could explore potential moderating and mediating factors that may influence the relationships between technological, organizational, and environmental constructs and adoption intention. For example, variables such as user experience, digital literacy, or perceived enjoyment could serve as moderators, while trust, satisfaction, or perceived usefulness may act as mediators. Investigating these mechanisms can provide deeper insights into how and why users decide to adopt Metaverse technologies.

In light of these results, cross-cultural and contextual variations should be examined. Since user perceptions and adoption behaviours may differ across cultural, organizational, or industry contexts, future research should investigate how cultural norms, organizational structures, and industry-specific characteristics impact adoption. Such studies can enhance the generalizability of findings and inform tailored strategies for diverse contexts.

Considering the dynamic nature of technology, longitudinal studies are recommended to examine changes in adoption intention and behaviour over time. This approach can shed light on the sustainability of user engagement, factors that influence continued usage, and the impact of evolving technological features on adoption patterns.

Taking into account the diversity of users, research should expand to include employees from different sectors, students, and general consumers. Exploring differences in adoption intention across demographic groups, skill levels, and technology exposure can reveal nuanced insights and guide more inclusive Metaverse design and deployment strategies.

Furthermore, emerging technological and social trends should be integrated into future research. As the Metaverse continues to evolve, studies could examine the effects of innovations such as AI, VR/AR enhancements, virtual communities, and digital collaboration on adoption intention. Understanding these trends can provide actionable guidance for platform developers and organizational decision-makers.

Finally, policy and ethical implications should be considered. Future research could investigate the role of governmental policies, regulatory frameworks, and ethical issues, including data privacy, security, and digital equity, in shaping adoption behaviours. These studies can inform recommendations for policymakers and organizations to ensure safe, responsible, and equitable adoption of immersive digital technologies.

10. Patents

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References

[1] Almashawreh, R., Talukder, M., Charath, S. K., & Khan, M. I. AI adoption in Jordanian SMEs: The influence of technological and organizational orientations. *Global Business and Organizational Excellence*, 2024. **43**(4), 87-102. https://doi.org/10.1177/09721509241250273

[2] Analysis Group. *The potential global economic impact of the metaverse*. Analysis Group, 2022. https://www.analysisgroup.com/globalassets/insights/publishing/2022-the-potential-global-economic-impact-of-the-metaverse.pdf

[3] Badghish, S., & Soomro, Y. A. Artificial intelligence adoption by SMEs to achieve sustainable business performance: Application of technology–organization–environment framework. *Sustainability*, 2024. **16**(5), 1864. https://doi.org/10.3390/su16051864

[4] Bekos, G. S., Chari, S., Marikyan, D., & Papagiannidis, S. Metaverse adoption for competitive edge: The role of implementation capability and willingness to change. *Decision Support Systems*, 2025. 189, 114385. https://doi.org/10.1016/j.dss.2024.114385

[5] Bentler, P. M., & Bonett, D. G. Significance tests and goodness-of-fit in the analysis of covariance structures. *Psychological Bulletin*, 1980. 88(3), 588–606. https://doi.org/10.1037/0033-2909.88.3.588

[6] Browne, M. W., & Cudeck, R. Alternative ways of assessing model fit. In Bollen, K. A., & Long, J. S. (Eds.), *Testing structural equation models*, 1993. pp. 136–162. Sage.

[7] C40 Cities. *Bangkok*. C40 Cities, 2024. https://www.c40.org/cities/bangkok/

[8] Cheng, Y., Jiang, H., & Dave, K. Leveraging the metaverse ecosystem: How institutional factors, adoption of metaverse-related technologies, and absorptive capacity drive performance in high-tech small and medium-sized enterprises. *Technological Forecasting and Social Change*, 2024. 203, 123429. https://doi.org/10.1016/j.techfore.2024.123429

[9] Davis, F. D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 1989. **13**(3), 319–340. https://doi.org/10.2307/249008

[10] Deloitte. *The metaverse in Asia: Strategies for accelerating economic impact*. Deloitte, 2022. https://www.marketing-interactive.com/metaverse-asia-gdp-1-4trillion-2035

[11] Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., et al. Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 2022. 66, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

[12] Firman, A., Chau, K. Y., Walawalkar, A. M., & Moslehpour, M. Navigating the future: Envisioning metaverse adoption in Indonesian tourism through the technological–organizational–environment (TOE) framework. *Journal of Theoretical and Applied Electronic Commerce Research*, 2025. **20**(2), 118. https://doi.org/10.3390/jtaer20020118

[13] Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. *Multivariate data analysis*. 8th ed., Cengage Learning, 2019.

[14] Hasani, T., Rezania, D., & Mohammadi, M. Towards a framework for successful metaverse adoption in small and medium-sized enterprises: An exploratory study. *International Journal of Engineering Business Management*, 2024. 16, 1–34. https://doi.org/10.1177/18479790241257118

[15] Hancock, G. R., & Mueller, R. O. Rethinking construct reliability within latent variable systems. In Cudeck, R., du Toit, S., & Sörbom, D. (Eds.), *Structural equation modeling: Present and future—A Festschrift in honor of Karl Jöreskog*, 2001.195–216. Scientific Software International.

[16] Hu, L., & Bentler, P. M. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 1999. 6(1), 1–55. https://doi.org/10.1080/10705519909540118

[17] Ifinedo, P. Technology acceptance by health professionals in Canada: An analysis with a modified UTAUT model. *Proceedings of the 45th Hawaii International Conference on System Sciences*, 2012. pp. 2937–2946. https://doi.org/10.1109/HICSS.2012.556

[18] Khin, S., & Ho, T. C. Digital technology, digital capability and organizational performance: A mediating role of digital innovation. *International Journal of Innovation Science*, 2019. 11(2), 177–195. https://doi.org/10.1108/IJIS-08-2018-0083

[19] Kline, R. B. *Principles and practice of structural equation modeling*. 4th ed., Guilford Press, 2016.

[20] Kiatsangsilp, D., & Pankham, S. Factors influencing digital technology adoption for the sustainable growth of SMEs in Thailand. *International Journal of Advanced and Applied Sciences*, 2025. **12**(7), 246–256. https://doi.org/10.21833/ijaas.2025.07.025
[21] Kumar, A., & Shankar, A. Building a sustainable future with enterprise metaverse in a data-driven era: A technology–organization–environment (TOE) perspective. *Journal of Retailing and Consumer Services*, 2024. 81, 103986. https://doi.org/10.1016/j.jretconser.2024.103986
[22] Ledesma-Chaves, P., Gil-Cordero, E., Navarro-Garcia, A., & Maldonado-López, B. Satisfaction and performance expectations for the adoption of the metaverse in tourism SMEs. *Journal of Innovation & Knowledge*, 2024. **9**(3), 100535. https://doi.org/10.1016/j.jik.2024.100535
[23] Misirlis, N., & Munawar, H. B. An analysis of the technology acceptance model in understanding university students' behavioral intention to use metaverse technologies. *arXiv preprint*, 2023. arXiv:2302.02176. https://arxiv.org/abs/2302.02176
[24] Mostafa, M. Exploring the potential of metaverse adoption in higher education. *SAGE Open*, 2022. 12(1), 215824402211086. https://doi.org/10.1177/215824402211086
[25] Office of Small and Medium Enterprises Promotion. *SMEs statistics report in Thailand*. Office of Small and Medium Enterprises Promotion, 2023. https://www.sme.go.th
[26] Oliveira, T., & Martins, M. F. Literature review of information technology adoption models at firm level. *Electronic Journal of Information Systems Evaluation*, 2011. **14**(1), 110–121.
[27] Ramtiyal, B., Soni, G., Jain, V., Shah, B., & Vijayvargy, L. Unraveling the aspects of metaverse adoption in the supply chains of small-scale enterprises with TOE framework. *The International Journal of Logistics Management*, 2025. https://www.scilit.com/publications/3883059b373808d4d89faaa693f292b0
[28] Rehman, A., Behera, R. K., Islam, M. S., Elahi, Y. A., Abbasi, F. A., & Imtiaz, A. Drivers of metaverse adoption for enhancing marketing capabilities of retail SMEs. *Technology in Society*, 2024. 79, 102704. https://doi.org/10.1016/j.techsoc.2024.102704
[29] Rogers, E. M. *Diffusion of innovations*. 5th ed., Free Press, 2003.
[30] Saridakis, G., Khan, Z., Knight, G., Idris, B., Mitra, J., & Khan, H. A look into the future: The impact of metaverse on traditional theories and thinking in international business. *Management International Review*, 2024. **64**(4), 597–632. https://doi.org/10.1007/s11575-024-00550-8
[31] Sartamorn, S., & Oe, H. Metaverse marketing for community development: Revitalization of traditional industrial sectors in Thailand. In *Advances in National Brand and Private Label Marketing: Ninth International Conference*, 2022.121–126. Springer International Publishing.
[32] Sastararuji, D., Hoonsopon, D., Pitchayadol, P., & Chongstitvatana, P. Cloud accounting adoption in Thai SMEs amid the COVID-19 pandemic: An explanatory case study. *Journal of Innovation and Entrepreneurship*, 2022. **11**(1), 43. https://doi.org/10.1186/s13731-022-00234-3
[33] Schumacker, R. E., & Lomax, R. G. *A beginner's guide to structural equation modeling*. 4th ed., Routledge, 2016.
[34] Shahzad, F., & Zhang, Q. Leveraging the metaverse ecosystem: How institutional factors, adoption of metaverse-related technologies, and absorptive capacity drive performance in high-tech small and medium-sized enterprises. *Information & Management*, 2025. **62**(2), 104080. https://doi.org/10.1016/j.im.2024.104080
[35] Sritong, C., Sawangproh, W., & Teangsompong, T. Unveiling the adoption of metaverse technology in Bangkok metropolitan areas: A UTAUT2 perspective with social media marketing and consumer engagement. *PLOS ONE*, 2024. **19**(6), e0304496. https://doi.org/10.1371/journal.pone.0304496
[36] Thawesaengskulthai, N., Chatmarathong, A., & Koiwanit, J. Impact and policy supporting Thailand innovation-driven enterprise: Orchestrating university innovation and entrepreneurship ecosystem with public and private stakeholders. *Journal of Innovation and Entrepreneurship*, 2024. **13**(1), 16. https://doi.org/10.1186/s13731-024-00371-x
[37] The Nation. Thai developers warn they can't succeed alone, call for collaboration in metaverse. *The Nation Thailand*, 2022. https://www.nationthailand.com/tech/ed-tech/40019177
[38] Tornatzky, L. G., & Fleischer, M. *The processes of technological innovation*. Lexington Books, 1990.
[39] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 2003. **27**(3), 425–478. https://doi.org/10.2307/30036540
[40] World Bank. *Thailand economic monitor: Unleashing growth – Innovation, SMEs and startups*. World Bank Group, 2025. https://www.worldbank.org/en/country/thailand/publication/thailand-economic-monitor-february-2025-unleashing-growth-innovation-smes-and-startups
[41] World Bank. *Thailand economic monitor February 2025: Unleashing growth – Innovation, SMEs and startups*. World Bank Group, 2025. https://www.worldbank.org/en/country/thailand/publication/thailand-economic-monitor-february-2025-unleashing-growth-innovation-smes-and-startups
[42] World Bank. *Thailand economic monitor July 2024: Unlocking the growth potential of secondary cities*. World Bank Group, 2024. https://www.worldbank.org/en/country/thailand/publication/temjuly2024
[43] World Economic Forum. *Social implications of the metaverse*. World Economic Forum, 2022. https://www.weforum.org/publications/social-implications-of-the-metaverse/