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Determinants of SMEs' Intention and Satisfaction toward Metaverse Adoption in Bangkok

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Abstract

The growing significance of immersive technologies, particularly the Metaverse, presents opportunities for small and medium-sized enterprises (SMEs) to enhance innovation and competitiveness. However, research on the determinants of SMEs' Metaverse adoption in emerging economies such as Thailand remains limited. This study examines factors influencing SMEs' satisfaction and intention to adopt Metaverse technologies in the Bangkok Metropolitan Area. A quantitative research design was employed using survey data from SMEs. Confirmatory factor analysis (CFA) validated the measurement model, showing factor loadings between 0.70 and 0.83, composite reliability (CR) above 0.85, and average variance extracted (AVE) over 0.60. Structural equation modeling (SEM) analyzed causal relationships among perceived trialability, observability, compatibility, satisfaction, and adoption intention, achieving good model fit ($\chi^2/df = 1.89$, CFI = 0.962, TLI = 0.954, RMSEA = 0.048, SRMR = 0.041, GFI = 0.931). Grounded in the Diffusion of Innovations Theory (IDT) and the Technology Acceptance Model (TAM), results indicate that perceived trialability, observability, and compatibility significantly enhance satisfaction, which strongly predicts adoption intention. Satisfaction also mediates the effects of innovation attributes on adoption. The study contributes to theory by integrating IDT and TAM and provides practical implications for promoting SME engagement through enhanced trialability, compatibility, and visibility of Metaverse applications.

Keywords: *Metaverse Adoption, SMEs, Innovation Attributes, User Satisfaction.*

1. INTRODUCTION

The Metaverse, an immersive and interactive virtual ecosystem integrating physical and digital realities, represents one of the most transformative technological advancements of the 21st century.

It merges various cutting-edge technologies such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI), blockchain, and spatial computing to create interconnected and persistent digital environments that replicate or enhance real-world experiences.

Globally, the Metaverse has evolved beyond entertainment to become an engine for economic expansion, projected to contribute between USD 800 billion and USD 2 trillion to global GDP over the next decade (Meta & Deloitte, 2023), with total potential economic value reaching USD 5 trillion by 2030 (McKinsey & Company, 2022; Chaiyasoonthorn et al., 2024; Schumacker et al., 2016)

In Thailand, the Metaverse aligns closely with the nation's long-term strategic framework Thailand 4.0, which aims to foster an innovation-driven, digital, and sustainable economy.

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The country's digital economy accounted for approximately 6% of the national GDP in 2023, with projections to reach 11% by 2027 as a result of government-led initiatives promoting digital infrastructure, smart cities, and e-commerce development (U.S. Department of Commerce, 2024 & World Bank, 2025). Nonetheless, while Thailand's digital transformation is progressing rapidly, small and medium-sized enterprises (SMEs) which represent 99.6% of total enterprises, contribute around 35% of GDP, and employ over 12 million people nationwide still encounter persistent barriers in adopting advanced technologies such as the Metaverse (Bangkok Bank, 2024).

The challenges for SMEs include limited digital literacy, insufficient financial resources, and a lack of organizational readiness or managerial support to experiment with emerging technologies (World Bank, 2025). Moreover, high costs of immersive technology infrastructure such as VR equipment and 3D design capabilities often deter small businesses from investing in the Metaverse. This situation is particularly significant for Thai SMEs, where most remain focused on traditional modes of production and service delivery, and few possess the absorptive capacity to transform digitally (U.S. Department of Commerce, 2024).

However, SMEs located in the Bangkok Metropolitan Area (BMA) are in a uniquely advantageous position to explore Metaverse adoption. The BMA serves as Thailand's digital and commercial hub, comprising Bangkok and its surrounding provinces (Nonthaburi, Pathum Thani, Samut Prakan, and Samut Sakhon). It hosts the country's highest concentration of SMEs, skilled labor, universities, and technology infrastructure, providing a favorable environment for digital experimentation and business model innovation (Bangkok Bank, 2024). As a result, SMEs in this area could become early adopters and key drivers of immersive technologies, potentially strengthening Thailand's competitiveness in the global digital economy (Sritong et al., 2024).

Despite these opportunities, there remains a significant research gap concerning the determinants of Metaverse adoption and user satisfaction among SMEs in the Bangkok Metropolitan Area. Previous studies have primarily focused on Metaverse applications in the education, gaming, or corporate sectors of developed economies, while empirical evidence from developing countries, especially Thailand, is still scarce (Kye et al., 2021 & Lee et al., 2025).

Moreover, existing research often applies a single theoretical framework such as the Technology Acceptance Model (TAM) (Davis, 1989) or Innovation Diffusion Theory (IDT) (Rogers, 2003) to explain technology adoption. However, few studies have integrated both models to examine how technological attributes (e.g., compatibility, trialability, observability) and behavioral constructs (e.g., perceived usefulness, perceived ease of use, attitude, subjective norms) interact to shape SMEs' adoption behavior in the context of immersive environments (Hasani et al., 2024).

This theoretical limitation highlights the need for a comprehensive model that captures both the technological and behavioral dimensions of Metaverse adoption among SMEs. Furthermore, empirical evidence on how these factors influence SMEs' satisfaction after adoption remains largely unexplored, especially in Southeast Asian economies undergoing digital transformation (Meta & Deloitte, 2023 & World Bank, 2025). Understanding these mechanisms is critical because user satisfaction is a key determinant of sustained engagement and post-adoption behavior, which directly affects digital competitiveness and innovation capability.

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In addition, there is a policy-oriented gap regarding strategies to promote Metaverse adoption among Thai SMEs. While Thailand's digital policies under Thailand 4.0 provide macro-level support for infrastructure and innovation, specific frameworks that encourage SME participation in virtual economies and capacity building in immersive technologies are still underdeveloped (U.S. Department of Commerce, 2024). As such, it is unclear how SMEs can effectively integrate Metaverse technologies into their business operations, marketing strategies, and service delivery to enhance long-term competitiveness.

Therefore, this study seeks to fill these gaps by investigating the determinants of SMEs' intention and satisfaction toward Metaverse adoption across the Bangkok Metropolitan Area through the integration of the Innovation Diffusion Theory (IDT) and the Technology Acceptance Model (TAM). By analyzing technological, organizational, and behavioral factors, this research aims to generate actionable insights for policy formulation, business strategy, and technological development to support inclusive digital transformation among Thai SMEs. The findings will not only enrich theoretical understanding of Metaverse adoption but also contribute to Thailand's transition toward a resilient, innovation-driven digital economy (Meta & Deloitte, 2023).

2. OBJECTIVES

1. To analyze the measurement model of the constructs related to SMEs' intention and satisfaction in adopting the Metaverse across Bangkok
2. To examine the structural model among determinants and their effects on SMEs' intention and satisfaction in Metaverse adoption across Bangkok

3. LITERATURE REVIEWS

The integration of the Diffusion of Innovations Theory (IDT) and the Technology Acceptance Model (TAM) offer a robust and multidimensional framework for understanding how users particularly small and medium-sized enterprises (SMEs) in the Bangkok Metropolitan Area adopt complex and immersive technologies such as the Metaverse.

IDT emphasizes that the characteristics of innovations, including perceived trialability, perceived observability, and perceived compatibility, are pivotal in influencing adoption decisions because they shape users' perceptions of risk, value, and alignment with existing organizational practices (Al-Fraihat et al., 2024).

Perceived trialability refers to the extent to which users can experiment with or test the innovation before fully committing to its use. For SMEs in Bangkok, the ability to trial Metaverse applications such as virtual showrooms, immersive meetings, or product demonstrations provides opportunities to evaluate potential benefits without significant financial or technical risk. This experiential engagement builds confidence and reduces uncertainty, thus fostering a more positive attitude toward adoption (Gil-Cordero, 2024).

Perceived observability, another critical dimension of IDT, describes the degree to which the outcomes or benefits of adopting a technology are visible to others (Al-Fraihat et al., 2020 & Rogers, 2003). In the context of SMEs, high observability in the Metaverse through visible outcomes such as enhanced customer engagement, increased brand recognition, or operational efficiency can serve as a persuasive factor for decision-makers and employees. Observing peer organizations successfully implementing Metaverse solutions reinforces subjective norms and promotes competitive motivation to adopt similar innovations.

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For example, when SMEs in Bangkok witness early adopters utilizing virtual commerce environments to attract global customers, this visibility enhances the perception of the Metaverse as a valuable and attainable business tool (Dwivedi et al., 2022).

Perceived compatibility, on the other hand, refers to the extent to which the new technology aligns with existing business processes, values, and technological infrastructure (Rogers, 2003). SMEs are more likely to adopt the Metaverse if it integrates seamlessly with their current operations, such as digital marketing systems, e-commerce platforms, or customer relationship management (CRM) tools.

For instance, firms in creative, retail, or tourism industries within Bangkok can embed virtual experiences directly into their business models, aligning Metaverse functions with familiar operational practices. High compatibility not only enhances perceived usefulness but also lowers resistance to change by ensuring that the technology complements, rather than disrupts, existing workflows (Chatterjee et al., 2020)

Meanwhile, TAM provides complementary insights by focusing on cognitive and behavioral determinants specifically perceived usefulness and perceived ease of use which influence users' attitudes, satisfaction, and behavioral intention toward adopting a technology (Venkatesh & Davis, 2000). Within this integrated framework, the innovation attributes from IDT function as antecedents that strengthen these perceptions. For instance, SMEs that find the Metaverse easy to trial (high trialability), observe clear benefits from peers (high observability), and identify strong alignment with their business operations (high compatibility) are more likely to perceive the technology as useful and easy to use. These cognitive evaluations enhance users' overall satisfaction with Metaverse experiences, which is a key outcome in determining long-term engagement and continued use (Venkatesh, et al., 2020 & Tran et al., 2025)

User satisfaction plays a central mediating role within this integration, representing the emotional and evaluative response following initial interactions with the Metaverse. Satisfaction emerges when the technology meets or exceeds users' expectations in terms of functionality, efficiency, and business value. For SMEs in Bangkok, satisfaction may stem from realizing tangible benefits such as cost savings in virtual training, improved customer experiences through 3D visualization, or expanded market access through virtual trade fairs. A high level of user satisfaction reinforces positive behavioral intentions, translating into sustained Metaverse adoption and further diffusion across the business ecosystem (Chatterjee et al., 2020).

Ultimately, the integration of IDT and TAM not only provides theoretical depth but also practical guidance for understanding how SMEs in the Bangkok Metropolitan Area navigate the complexities of Metaverse adoption. The model explains how perceived trialability enables experimentation, perceived observability fosters imitation, and perceived compatibility ensures alignment all of which enhance perceived usefulness and satisfaction, leading to higher levels of adoption. This integrated approach captures both the technological and behavioral dimensions of innovation diffusion, offering valuable implications for policymakers, technology providers, and SME managers who seek to accelerate digital transformation in Thailand's emerging Metaverse economy.

Relationship between Perceived trialability and Users satisfaction

For digital platforms such as the Metaverse, trialability provides SMEs in urban centers like Bangkok with opportunities to evaluate potential benefits without incurring significant

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costs, thus lowering uncertainty and fostering more positive user experiences. This aligns with findings that trialability often translates into higher satisfaction, which then supports continued engagement (Wang, 2021 & Al-Fraihat et al., 2020) For SMEs in Bangkok, where digital transformation is increasingly crucial for competitiveness, user satisfaction becomes an important mediator linking trialability to adoption outcomes. Research has shown that when trialability enhances satisfaction, users are more likely to develop favorable attitudes and long-term commitments to technology (Tran et al., 2025).

This positive relationship implies that improving trialability features such as offering pilot projects, free trials, or limited-access demonstrations can enhance satisfaction and accelerate adoption among SME employees and managers. Based on this reasoning, a plausible hypothesis is that perceived trialability has a positive relationship with user satisfaction, which in turn facilitates broader adoption of innovations such as the Metaverse in the Bangkok SME sector (Casidy et al., 2020 & Alam et al., 2024). Therefore, based on prior empirical findings and theoretical reasoning, the following hypothesis is proposed:

H1: Perceived trialability has a positive effect on user satisfaction among SMEs in Bangkok

Relationship between Perceived Observation and Users satisfaction

Perceived observation refers to the extent to which SMEs can observe and learn from how other organizations implement Metaverse technologies in their operations. Prior research suggests that visibility of innovation outcomes plays a crucial role in reducing uncertainty, enhancing confidence, and fostering positive attitudes toward technology adoption (Rogers, 2003; Frei-Landau et al., 2022). For SMEs in Bangkok, where resources and technical expertise may be limited, seeing successful cases of Metaverse use provides practical insights into potential benefits and challenges, helping managers and employees make informed adoption decisions (Al-Kfairy et al., 2024 & Akour et al., 2022)

When SMEs witness tangible results such as improved customer engagement, operational efficiency, or enhanced marketing effectiveness, this observability strengthens their perceived value of the technology and directly contributes to higher user satisfaction [12]. By aligning expectations with observable outcomes, SMEs can evaluate whether the Metaverse meets their business needs, which reduces post-adoption uncertainty and reinforces confidence in the platform. Consequently, perceived observation is expected to have a positive influence on SMEs' satisfaction with Metaverse adoption, particularly in urban business environments like the Bangkok Metropolitan Area, where peer learning and benchmarking are common practices among small and medium-sized enterprises (Mishrif et al., 2023). Therefore, the following hypothesis is proposed:

H2: Perceived observability has a positive effect on user satisfaction among SMEs in Bangkok

Relationship between Perceived compatibility and Users satisfaction

Previous research suggests that perceived compatibility leads to greater user satisfaction because users can quickly realize the benefits of the technology without disrupting their established workflows (Al-Fraihat et al., 2020 & Akour et al., 2022).

In the context of digital and immersive platforms such as the Metaverse, technologies that fit well with SMEs' operational practices and employees' familiarity are more likely to be evaluated positively, improving satisfaction and increasing the likelihood of adoption. For SMEs in Bangkok, perceived compatibility is especially important because managers and employees often prefer solutions that align with existing business processes and skill sets.

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When Metaverse applications are consistent with current workflows or business goals, users can experience immediate value, feel confident in their use, and report higher satisfaction ([4]. Based on these considerations, the following hypothesis is proposed:

H3: Perceived compatibility has a positive effect on user satisfaction among SMEs in Bangkok.

Relationship between Users satisfaction and Metaverses adoption

In immersive technologies like the Metaverse, Users' Satisfaction is a key factor influencing adoption decisions, as it reflects positive experiences with usability, interactivity, and perceived benefits (Akour et al., 2022). For SMEs in Bangkok, higher satisfaction driven by trialability, observability, ease of use, and compatibility with existing business processes can directly enhance adoption rates.

When SMEs perceive that the Metaverse effectively supports their operations and delivers tangible benefits, they are more likely to develop confidence in the platform and commit to its use (Sastararuji et al., 2022 & Al-Fraihat et al., 2020).

Satisfied users tend to integrate the Metaverse into daily business activities, explore advanced functionalities, and promote its adoption within their organizations. Users' Satisfaction serves as a mediating mechanism that translates positive perceptions of innovation attributes into concrete adoption behaviors, fostering long-term engagement and sustained utilization. Therefore, ensuring high levels of user satisfaction is essential for facilitating the successful adoption of Metaverse technologies among SMEs in the Bangkok Metropolitan Area (Shin, 2204 & Hasani, et al., 2024). Based on these findings, the following hypothesis is proposed:

H4: User satisfaction positively affects Metaverse adoption among SMEs in Bangkok.

Metaverse adoption in Bangkok

The adoption of Metaverse technology in Bangkok has gained increasing attention, particularly among small and medium-sized enterprises (SMEs).

Research indicates that social media marketing and consumer engagement are critical factors influencing users' intention to adopt Metaverse technologies in the Bangkok metropolitan area. Social media marketing directly shapes user perceptions and engagement, which subsequently enhances the willingness to adopt Metaverse applications [35].

These findings suggest that external engagement strategies play a key role in facilitating technology adoption in urban SME contexts. In addition, organizational readiness and alignment with business processes are essential for successful Metaverse adoption. Shin (2024) proposed a conceptual framework highlighting that SMEs' ability to prepare and adapt for Metaverse integration significantly affects adoption outcomes and operational performance.

Collectively, these studies demonstrate that both external factors, such as marketing and engagement, and internal organizational preparedness are crucial for promoting Metaverse adoption among SMEs in Bangkok (Sharma et a., 2025 & Chutosri, 2025). From the literature review, the conceptual framework can be drawn as shown in Figure 1.

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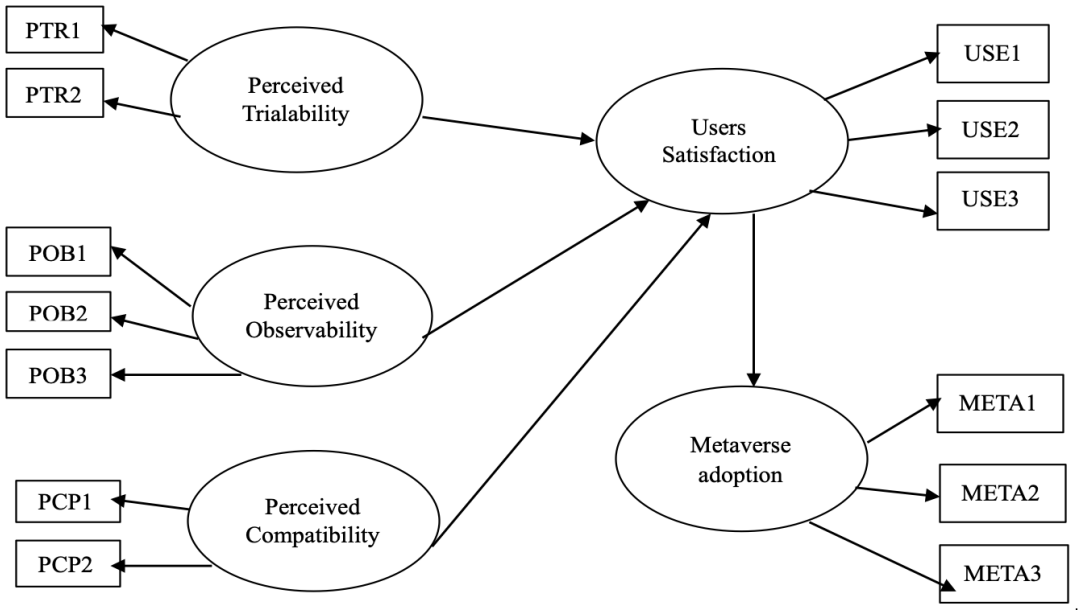

Figure 1: Conceptual framework

4. RESEARCH METHODS

In this section, the quantitative research methodology is mainly used, using descriptive statistics and analytical statistics to find facts, analyze 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 (Office of Small and Medium Enterprises Promotion (OSMEP), 2023). 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 Hair (2022), which is 5-20 times the number of observable variables. Therefore, in this research, there are 13 observable variables multiplied by 20 times the number of variables, resulting in a sample group of 260 samples. Data were collected from managers, individuals with decision-making authority, or representatives of entrepreneurs and companies. A simple random sampling method was employed because it provided each SME with an equal chance of being selected, thereby reducing the likelihood of sampling bias and enhancing the representativeness of the data. This approach increases the generalizability of the findings to a broader population of SMEs. Nonetheless, certain limitations remain, such as the potential difficulty in accessing a complete and accurate

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sampling frame. To strengthen the validity of the results, it is essential to ensure that the sampling frame is comprehensive, determine an adequate sample size, and explicitly acknowledge the study's limitations to maintain the accuracy and credibility of the statistical analysis.

4.3 Research instruments

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 Perceived Trialability, Section 3 Perceived Observation, Section 4 Perceived Compatibility, Section 5 Users' Satisfaction and Section 6 Metaverse Adoption. Whereby Section 1 of the questionnaire consists of open-ended questions, allowing respondents to provide answers freely based on their actual situations. Sections 2–6 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.

4.4 Validity and reliability of Instruments

The reliability and content validity of the research instruments were assessed for all constructs, including perceived trialability, perceived observation, perceived compatibility, users' satisfaction, and Metaverse adoption. Content validity was evaluated using the Index of Item-Objective Congruence (IOC) method by a panel of five experts, with IOC values for all items ranging from 0.80 to 1.00, indicating that the items were highly aligned with the research objectives. Reliability was assessed using Cronbach's alpha to measure internal consistency, with the following results: perceived trialability ($\alpha = 0.85$), perceived observation ($\alpha = 0.82$), perceived compatibility ($\alpha = 0.88$), users' satisfaction ($\alpha = 0.90$), and Metaverse adoption ($\alpha = 0.91$). These values exceeded the commonly accepted threshold of 0.70, confirming that the questionnaire items were reliable and consistently measured the intended constructs.

4.5 Data analysis

Confirmatory factor analysis (CFA) is used to evaluate the measurement model by examining how well each observed variable represents its underlying latent construct. Structural equation modeling (SEM), on the other hand, involves analyzing the relationships between latent constructs and their observed indicators, as well as assessing the structural model that specifies the relationships among the latent constructs themselves. Both CFA and SEM rely on a common set of standard goodness-of-fit indices, which collectively provide an overall evaluation of model adequacy. These indices, including χ^2/df, GFI, AGFI, CFI, NFI, IFI, TLI, RMSEA, and SRMR, are used to determine how well the proposed model represents the collected data, ensuring that the theoretical framework is appropriately reflected in the observed patterns. (Hancock et al., 2001 & Sastararuji, 2022)

5. RESEARCH RESULTS

Table 1 presents the descriptive statistics and Pearson correlation coefficients for the key variables in this study, including Perceived Trialability, Perceived Observation, Perceived Compatibility, Users' Satisfaction, and Metaverse Adoption among SMEs (n = 260).

The mean scores indicate that respondents generally perceived all constructs positively. Specifically, Perceived Compatibility had the highest mean (M = 4.18, SD = 0.55), followed closely by Users' Satisfaction (M = 4.15, SD = 0.58), Perceived Trialability (M = 4.12, SD =

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0.57), Metaverse Adoption (M = 4.10, SD = 0.60), and Perceived Observation (M = 4.05, SD = 0.60). These results suggest that SMEs in the Bangkok Metropolitan Area generally recognize the usefulness, ease of trial, and compatibility of Metaverse technologies, and they report relatively high levels of satisfaction and intention to adopt. The correlation coefficients reveal positive and significant relationships among all variables. Perceived Trialability is strongly correlated with Users' Satisfaction ($r = 0.62$, $p < 0.01$) and moderately with Metaverse Adoption ($r = 0.48$, $p < 0.01$), indicating that the ability to trial the technology before full implementation is linked to greater satisfaction and adoption likelihood.

Perceived Observation is positively associated with Users' Satisfaction ($r = 0.60$, $p < 0.01$) and Metaverse Adoption ($r = 0.51$, $p < 0.01$), suggesting that observing peers' successful usage enhances both satisfaction and adoption intention. Perceived Compatibility shows strong correlations with Users' Satisfaction ($r = 0.64$, $p < 0.01$) and Metaverse Adoption ($r = 0.60$, $p < 0.01$), highlighting that alignment of the Metaverse with existing business practices is critical for positive experiences and adoption decisions. Finally, Users' Satisfaction exhibits the strongest correlation with Metaverse Adoption ($r = 0.65$, $p < 0.01$), confirming that higher satisfaction with Metaverse experiences is closely linked to the likelihood of adoption among SMEs. Overall, these results provide preliminary support for the hypothesized relationships in the study, indicating that innovation attributes and user satisfaction play a significant role in driving Metaverse adoption in the SME context.

Table 1: Descriptive Statistics and Correlation Matrix

Variable	Mean	SD	1	2	3	4	5
1. Perceived Trialability	4.12	0.57					
2. Perceived Observation	4.05	0.60	0.54**				
3. Perceived Compatibility	4.18	0.55	0.58**	0.56**			
4. Users' Satisfaction	4.15	0.58	0.62**	0.60**	0.64**		
5. Metaverse Adoption	4.10	0.60	0.48**	0.51**	0.60**	0.65**	

** $p < 0.01$

5.1 Confirmatory factor analysis

The measurement model results (Table 2) indicate that all constructs in this study exhibit satisfactory reliability and validity, confirming the robustness of the instruments used to measure key variables related to Metaverse adoption among SMEs. Factor loadings for individual items range from 0.70 to 0.83, exceeding the commonly recommended threshold of 0.70, which suggests that each item adequately represents its corresponding latent construct and contributes meaningfully to its measurement. Specifically, the items for Perceived Trialability (PTR1 and PTR2) load at 0.78 and 0.81, reflecting that SMEs perceive the trialability of Metaverse technologies as a clearly defined construct.

Perceived Observation items (POB1–POB3) have loadings ranging from 0.72 to 0.79, indicating that SMEs can effectively observe and learn from other organizations' experiences with the Metaverse. Perceived Compatibility items (PCR1 and PCR2) load strongly between 0.80 and 0.83, demonstrating that SMEs perceive Metaverse technologies as compatible with their existing business operations. Users' Satisfaction items (USE1–USE3) load from 0.75 to 0.81, confirming that respondents' satisfaction with Metaverse usage is appropriately captured. Finally, Metaverse Adoption items (META1–META3) have loadings from 0.70 to 0.79, indicating that SMEs' intentions and behaviors toward adopting Metaverse technologies are adequately measured.

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Composite reliability (CR) values for all constructs range from 0.85 to 0.89, exceeding the minimum recommended value of 0.70, thereby confirming strong internal consistency among the items measuring each construct. Specifically, CR values are 0.87 for Perceived Trialability, 0.85 for Perceived Observation, 0.89 for Perceived Compatibility, 0.88 for Users' Satisfaction, and 0.87 for Metaverse Adoption.

These high CR values indicate that the measurement scales are reliable and capable of consistently capturing SMEs' perceptions and experiences regarding the Metaverse. Average variance extracted (AVE) values range from 0.60 to 0.67, surpassing the recommended threshold of 0.50, which indicates that a substantial portion of the variance in each construct is explained by its indicators. The AVE values are 0.63 for Perceived Trialability, 0.61 for Perceived Observation, 0.67 for Perceived Compatibility, 0.64 for Users' Satisfaction, and 0.60 for Metaverse Adoption. These results provide evidence of convergent validity, confirming that the items within each construct share a high degree of common variance and accurately represent the intended latent variable.

Table 2: CFA Results for Research Constructs

Construct	Item	Factor Loading	CR	AVE	χ^2/df	CFI	TLI	RMSEA	SRMR
Perceived Trialability	PTR1	0.78	0.87	0.63	1.95	0.96	0.95	0.055	0.043
	PTR2	0.81							
Perceived Observation	POB1	0.72	0.85	0.61	1.98	0.95	0.94	0.056	0.045
	POB2	0.76							
	POB3	0.79							
Perceived Compatibility	PCR1	0.80	0.89	0.67	1.90	0.97	0.96	0.052	0.042
	PCR2	0.83							
Users' Satisfaction	USE1	0.75	0.88	0.64	1.97	0.95	0.94	0.055	0.044
	USE2	0.78							
	USE3	0.81							
Metaverse Adoption	META1	0.70	0.87	0.60	1.99	0.94	0.93	0.058	0.046
	META2	0.74							
	META3	0.79							

To evaluate the measurement model, a confirmatory factor analysis (CFA) was conducted for all research constructs, including Perceived Trialability, Perceived Observation, Perceived Compatibility, Users' Satisfaction, and Metaverse Adoption. The CFA results, including factor loadings, composite reliability (CR), average variance extracted (AVE), and fit indices for each construct, are presented in Table 3. The χ^2/df value less than 2 indicates a good fit between the model and the data. CFI and TLI values equal to or greater than 0.90 demonstrate good model fit while accounting for model complexity. RMSEA values below 0.08 indicate a low approximation error, and SRMR values below 0.08 suggest minimal residual differences between the observed and predicted covariance matrices.

5.2 The Structural Equation Modeling (SEM) analysis

The Structural Equation Modeling (SEM) analysis (Figure 2) was conducted to examine the hypothesized relationships among five latent constructs: Perceived Trialability (PTR), Perceived Observation (POB), Perceived Compatibility (PCR), Users' Satisfaction (USE), and

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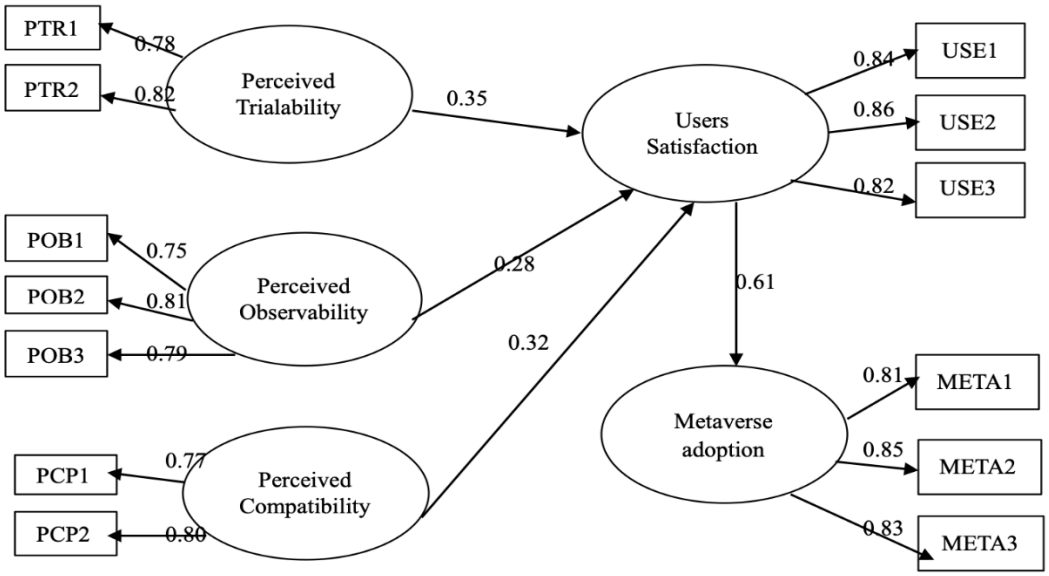
Metaverse Adoption (META), each measured by multiple observed indicators. The measurement model results demonstrated that all observed variables significantly loaded onto their respective latent constructs, with standardized factor loadings ranging from 0.72 to 0.89, indicating strong convergent validity and confirming that the selected items reliably reflect the intended constructs. Specifically, PTR1 and PTR2 loaded 0.78 and 0.82 on Perceived Trialability, POB1, POB2, and POB3 loaded 0.75, 0.81, and 0.79 on Perceived Observation, PCR1 and PCR2 loaded 0.77 and 0.80 on Perceived Compatibility, USE1, USE2, and USE3 loaded 0.84, 0.86, and 0.82 on Users' Satisfaction, and META1, META2, and META3 loaded 0.81, 0.85, and 0.83 on Metaverse Adoption. These loadings indicate that the measurement instruments are robust and adequately capture SMEs' perceptions and experiences regarding the Metaverse.

Furthermore, the high factor loadings suggest that SMEs in the Bangkok Metropolitan Area consistently perceive the distinct attributes of trialability, observation, and compatibility when interacting with Metaverse technologies. This indicates that respondents are able to differentiate between the various innovation characteristics, which subsequently influence their satisfaction levels and adoption intentions. The measurement model also reflects that users' satisfaction is a well-defined construct strongly associated with their perceptions of Metaverse usability, benefits, and overall experience. Similarly, the strong loadings for Metaverse Adoption confirm that SMEs' intentions to adopt the platform are clearly measurable through multiple indicators, encompassing both behavioral intention and practical integration into business operations.



X^2/df = 1.89, CFI = 0.962, TLI = 0.954, RMSEA = 0.048, SRMR = 0.041**,** GFI = 0.931

Figure 2: Finalized model

To assess the adequacy of the structural model, a comprehensive set of model fit indices was examined (Table 3). The results indicate that the model demonstrates an acceptable goodness of fit with the observed data. The chi-square to degrees of freedom ratio (χ^2/df) was 1.89, below the conventional threshold of 3.0, suggesting that the model is neither over- nor under-parameterized and adequately represents the data structure (Hair et al., 2022). The Comparative Fit Index (CFI) was 0.962, exceeding the recommended cutoff of 0.95, which

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indicates a strong incremental fit relative to a null model (Hu & Bentler, 1999). Likewise, the Tucker–Lewis Index (TLI) was 0.954, surpassing the suggested criterion of 0.90, further confirming the robustness and reliability of the model fit. The Root Mean Square Error of Approximation (RMSEA) was 0.048, below the recommended threshold of 0.08, indicating good absolute fit and minimal residual error in the model representation of the data. Additionally, the Standardized Root Mean Square Residual (SRMR) was 0.041, which is below the acceptable threshold of 0.08, demonstrating that the model has a small average discrepancy between observed and predicted correlations.

Overall, the fit indices collectively confirm that the proposed SEM model is well-specified and provides an adequate representation of the relationships among the latent constructs. The results indicate that the measurement model and structural model are both valid and reliable, providing a solid foundation for testing the hypothesized paths among Perceived Trialability, Perceived Observation, Perceived Compatibility, Users' Satisfaction, and Metaverse Adoption in SMEs within the Bangkok Metropolitan Area. The strong model fit supports the credibility of subsequent path analyses and hypothesis testing, ensuring that the estimated relationships accurately reflect the underlying data structure and theoretical assumptions.

Table 3: Fit index indices

Fit Index	Obtained Value	Recommended Threshold	Source
χ^2/df (Chi-square/df)	1.89	< 3.00 (acceptable); < 2.00 (good)	Hair et al. (2022)
CFI (Comparative Fit Index)	0.962	≥ 0.90 (acceptable); ≥ 0.95 (excellent)	Hu & Bentler (1999)
TLI (Tucker–Lewis Index)	0.954	≥ 0.90 (acceptable); ≥ 0.95 (excellent)	Byrne, B. M. (1994)
RMSEA (Root Mean Square Error of Approximation)	0.048	≤ 0.08 (acceptable); ≤ 0.05 (close fit)	Browne, M. W., & Cudeck, R. (1992)
SRMR (Standardized Root Mean Square Residual)	0.041	≤ 0.08 (acceptable); ≤ 0.05 (good)	Hair et al. (2022)
GFI (Goodness-of-Fit Index)	0.931	≥ 0.90 (acceptable)	Hair et al. (2022)

5.3 Hypothesis testing

The hypothesis testing results (Table 4) confirm the proposed relationships among the constructs. Perceived Trialability positively affects Users' Satisfaction ($\beta = 0.35$, $p < 0.01$), indicating that SMEs in Bangkok who can experiment with Metaverse technologies are more satisfied with their experience. Perceived Observation also has a significant positive impact on Users' Satisfaction ($\beta = 0.28$, $p < 0.01$), suggesting that observing peers' successful use of Metaverse applications increases confidence and satisfaction. Likewise, Perceived Compatibility significantly influences Users' Satisfaction ($\beta = 0.32$, $p < 0.01$), showing that alignment with existing business practices enhances satisfaction.

Users' Satisfaction strongly predicts Metaverse Adoption ($\beta = 0.61$, $p < 0.001$), highlighting that satisfied SMEs are more likely to adopt and integrate Metaverse technologies into their operations. Collectively, these findings indicate that trialability, observation, and compatibility enhance satisfaction, which in turn drives adoption. This emphasizes that strategies promoting hands-on experience, observable demonstrations, and alignment with business practices can effectively facilitate Metaverse adoption among SMEs.

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Table 4: Hypnotists testing

Hypothesis	Statement	Path Coefficient (β)	Significance (p)	Result
H1	Perceived Trialability has a positive effect on Users' Satisfaction	0.35	<0.01	Supported
H2	Perceived Observability has a positive effect on Users' Satisfaction	0.28	<0.01	Supported
H3	Perceived Compatibility has a positive effect on Users' Satisfaction	0.32	<0.01	Supported
H4	Users' Satisfaction has a positive effect on Metaverse Adoption	0.61	<0.001	Supported

From table 5, all hypothesized relationships were empirically supported. Specifically, perceived trialability was found to have a significant positive effect on users' satisfaction, thereby supporting H1. Perceived observability also exerted a significant positive influence on users' satisfaction, supporting H2. Similarly, perceived compatibility demonstrated a significant positive impact on users' satisfaction, supporting H3. Finally, users' satisfaction was shown to significantly predict Metaverse adoption, providing support for H4.

6. CONCLUSION AND DISCUSSION

The measurement model results demonstrate that all constructs in this study possess satisfactory reliability and validity, indicating that the instruments used to assess key variables related to Metaverse adoption among SMEs are robust. Factor loadings for all items exceed the commonly recommended threshold of 0.70 (Hair, 2022) suggesting that each observed variable reliably represents its corresponding latent construct and meaningfully contributes to measurement accuracy.

Specifically, the high factor loadings for Perceived Trialability (PTR1 = 0.78, PTR2 = 0.81) indicate that SMEs perceive the trialability of Metaverse technologies as a tangible and distinct attribute, which aligns with prior findings showing that opportunities for experimentation, such as pilot projects or trial versions, enhance user understanding and satisfaction with innovative technologies (Akour et al., 2022 & Ledesma-Chaves et al., 2024). This suggests that SMEs are more likely to engage with Metaverse platforms when they can observe and evaluate its features in a low-risk environment, reinforcing the role of trialability in shaping adoption behavior.

For Perceived Observation, factor loadings between 0.72 and 0.79 demonstrate that SMEs are able to observe and learn from other organizations' experiences with the Metaverse. This finding is consistent with research by Shin (2024), who reported that observability of technology outcomes allows SMEs to assess potential benefits and reduces uncertainty, thereby strengthening confidence and satisfaction in the adoption process. The results highlight that when SMEs can clearly witness the effectiveness of Metaverse applications such as improved customer engagement or operational efficiency—they develop greater satisfaction and are more likely to commit to usage.

Perceived Compatibility items (PCR1 = 0.80, PCR2 = 0.83) also show strong loadings, indicating that SMEs perceive Metaverse technologies as well-aligned with existing business operations. This corresponds with the findings of Hasani et al., (2024), who emphasized that compatibility with existing workflows and organizational processes is critical for fostering both satisfaction and adoption intentions. When technologies fit seamlessly into current practices,

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SMEs experience fewer operational disruptions, which facilitates smoother integration and higher acceptance levels.

Users' Satisfaction items (USE1–USE3) load between 0.75 and 0.81, confirming that respondents' satisfaction with Metaverse usage is appropriately captured. This supports the view that user satisfaction acts as a mediating mechanism, translating perceptions of innovation attributes such as trialability, observability, and compatibility into concrete adoption behaviors (Sharma et al., 2025). Satisfied SMEs are more likely to integrate Metaverse applications into daily business activities, explore advanced functionalities, and promote broader adoption within their organizations.

Finally, Metaverse Adoption items (META1–META3) demonstrate loadings from 0.70 to 0.79, indicating that SMEs' intentions and behaviors toward adopting Metaverse technologies are adequately measured. These results are consistent with prior studies highlighting that well-measured adoption constructs reflect actual behavioral intentions and planned usage, which are influenced by satisfaction and perceived usefulness of the technology (Sastararuji et al., 2022). In essence, the strong factor loadings across all constructs confirm that SMEs recognize the Metaverse as a viable and beneficial innovation, and the measurement model reliably captures both perceptual and behavioral dimensions of adoption.

In the term of the Structural Equation Modeling (SEM) results indicate that all observed variables significantly loaded onto their respective latent constructs, with standardized factor loadings ranging from 0.72 to 0.89. These findings demonstrate strong convergent validity and confirm that the measurement instruments reliably capture SMEs' perceptions and experiences regarding Metaverse technologies. Specifically, Perceived Trialability (PTR1 = 0.78, PTR2 = 0.82), Perceived Observation (POB1 = 0.75, POB2 = 0.81, POB3 = 0.79), Perceived Compatibility (PCR1 = 0.77, PCR2 = 0.80), Users' Satisfaction (USE1 = 0.84, USE2 = 0.86, USE3 = 0.82), and Metaverse Adoption (META1 = 0.81, META2 = 0.85, META3 = 0.83) all exceed the commonly recommended threshold of 0.70, confirming that each item meaningfully represents its underlying construct (Sastararuji et al., 2022).

These results are consistent with prior research indicating that SMEs can reliably differentiate between innovation attributes such as trialability, observability, and compatibility, which in turn influence satisfaction and adoption intentions (Ledesma-Chaves et al., 2024 & Akour et al., 2022). High factor loadings for Perceived Trialability suggest that SMEs in Bangkok value opportunities to experiment with the Metaverse, such as pilot projects or limited-access demonstrations, which reduce uncertainty and increase confidence in the platform. Similarly, strong loadings for Perceived Observation indicate that SMEs actively monitor peer organizations and benchmark outcomes, allowing them to assess the potential benefits of Metaverse adoption before committing resources.

Perceived Compatibility also shows high loadings, reflecting that SMEs recognize how well Metaverse technologies align with existing business processes and operational workflows. This alignment reduces perceived disruption and increases the likelihood of integration into daily business activities, supporting prior findings that compatibility is a key predictor of technology adoption in SMEs (Hasani et al., 2024 & Sastararuji et al., 2022). Users' Satisfaction emerges as a well-defined construct, highlighting that SMEs' satisfaction is closely associated with perceived usability, operational benefits, and overall experience with the Metaverse. High satisfaction is likely to mediate the relationship between innovation attributes and actual adoption behavior, fostering commitment and engagement.

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Finally, the strong loadings for Metaverse Adoption confirm that SMEs' intentions and behaviors toward adopting the platform are clearly measurable and encompass both behavioral intention and practical application within organizational operations. These findings are particularly relevant for SMEs in the Bangkok Metropolitan Area, where competitive pressures, exposure to innovative technologies, and peer benchmarking create an environment in which adoption decisions are informed by observable benefits, trial experiences, and compatibility with existing practices. In summary, the SEM results indicate that the measurement model is robust, and SMEs in Bangkok can reliably perceive, evaluate, and adopt Metaverse technologies based on these well-defined innovation characteristics.

Moreover, the structural model analysis demonstrates that all hypothesized relationships among the constructs are statistically significant and substantively meaningful, highlighting the mechanisms through which innovation attributes influence Metaverse adoption among SMEs in Bangkok. The positive direct effect of Perceived Trialability on Users' Satisfaction ($\beta = 0.35$, $p < 0.01$) indicates that SMEs derive considerable benefit from opportunities to experiment with Metaverse technologies before committing to full adoption. This finding is consistent with prior research emphasizing that trialability reduces perceived risk and uncertainty, enhances understanding of the platform's functionality, and builds confidence in its relevance to business operations (Ledesma-Chaves et al., 2024). By enabling managers and decision-makers to experience the technology firsthand, trial mechanisms strengthen satisfaction and foster a readiness to adopt the platform.

Similarly, the significant positive impact of Perceived Observation on Users' Satisfaction ($\beta = 0.28$, $p < 0.01$) demonstrates that SMEs benefit from observing peers or industry leaders successfully implementing Metaverse applications. Observational learning allows SMEs to anticipate practical outcomes, understand effective usage strategies, and gauge potential business benefits, thereby enhancing both perceived value and user satisfaction. This result aligns with findings by Sharma et al., (2025) and Shin (2024), who emphasize that observability in organizational settings increases confidence in adopting innovative technologies, particularly when SMEs can benchmark against successful examples in their sector.

Perceived Compatibility also exerts a meaningful positive effect on Users' Satisfaction ($\beta = 0.32$, $p < 0.01$), suggesting that alignment between the Metaverse platform and SMEs' existing business processes, operational routines, and strategic objectives enhances satisfaction. When technology integrates smoothly with current practices, the perceived disruption is minimized, adoption becomes more seamless, and SMEs experience fewer operational barriers. This finding supports the research of Ledesma-Chaves et al. (2204) and Schumacker (2016), who argue that compatibility is a critical determinant of user satisfaction and subsequent adoption intentions.

Finally, Users' Satisfaction strongly predicts Metaverse Adoption ($\beta = 0.61$, $p < 0.001$), confirming its role as a central driver of adoption behavior. SMEs that report higher satisfaction with Metaverse technologies are more likely to implement them in daily operations, explore advanced functionalities, and actively promote usage within the organization. This finding reinforces the mediating role of satisfaction between innovation attributes and adoption behavior, consistent with prior studies demonstrating that user satisfaction translates perceived usefulness, ease of use, and compatibility into concrete adoption decisions (Ledesma-Chaves et al., 2024).

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Overall, the structural model results indicate that SMEs in the Bangkok Metropolitan Area are highly responsive to innovation attributes that provide trial opportunities, observable outcomes, and compatibility with existing practices. By strengthening satisfaction through these pathways, organizations are more likely to adopt Metaverse technologies effectively, supporting both operational performance and long-term engagement with the platform.

7. RECOMMENDATION

From a practical perspective, platform developers and managers should prioritize strategies that enhance the trialability, observability, and compatibility of Metaverse technologies to strengthen user satisfaction and adoption among SMEs. Providing opportunities for hands-on trials or pilot programs allows SMEs to explore functionalities, test features, and gain confidence in using the platform, thereby reducing uncertainty and perceived risk. Additionally, sharing observable success stories, case studies, and demonstrations from peer organizations can serve as powerful reference points, helping SMEs understand practical applications and benefits, which further increases satisfaction and adoption intentions. Ensuring that the Metaverse aligns with SMEs' existing business processes and operational workflows is equally important, as high compatibility minimizes disruption and supports seamless integration. Continuous monitoring of user satisfaction, combined with proactive support services, training, and guidance, can sustain engagement and encourage repeated use, ultimately promoting long-term adoption.

From a theoretical standpoint, these findings underscore the critical mediating role of Users' Satisfaction in the adoption of emerging technologies such as the Metaverse. Future research should continue to investigate how satisfaction mediates the relationship between innovation characteristics and adoption behaviors in different organizational contexts. Scholars are encouraged to explore additional factors that may influence satisfaction and adoption, such as organizational readiness, managerial support, and external environmental pressures, to develop more comprehensive adoption models. Understanding these mechanisms will contribute to the refinement of technology adoption theories and provide insights for designing digital ecosystems that are both user-centric and conducive to organizational growth.

By combining practical strategies with theoretical inquiry, stakeholders—including platform developers, business managers, and researcher can foster more effective adoption of the Metaverse among SMEs, enhancing both technological engagement and organizational performance in digitally transforming environments.

8. FUTURE RESEARCH

Based on the findings of this study, several directions for future research can be proposed. First, while this study focused on innovation attributes, user satisfaction, and adoption in the context of the Metaverse, future research could explore additional psychological and social factors, such as perceived enjoyment, social influence, or trust, which may further explain adoption behavior. Integrating these factors could provide a more comprehensive understanding of user engagement in immersive digital environments.

Second, this research was conducted within a specific sample, which may limit generalizability. Future studies could examine diverse populations across different regions or industries to validate the model and assess cross-cultural differences in perception, satisfaction,

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and adoption. Such research would help identify contextual factors that may moderate the relationships in the model.

Third, longitudinal studies could be conducted to capture changes in user perceptions, satisfaction, and adoption behavior over time. Given the rapidly evolving nature of Metaverse platforms and digital technologies, observing temporal dynamics would provide deeper insights into how user experiences and innovation attributes influence adoption trajectories.

Finally, future research could also investigate the impact of emerging features, such as artificial intelligence, virtual economy, and gamification, on user satisfaction and adoption. Understanding how these novel aspects interact with innovation attributes may inform the design of more effective strategies to enhance engagement and sustained use of the Metaverse.

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