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Research Article

Metaverse Banking Service: Are We Ready to Adopt? A Deep Learning-Based Dual-Stage SEM-ANN Analysis

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Metaverse banking service is the transformation from online banking to a metaverse environment that allows customers to access banking services and interact with representatives in a virtual environment. The metaverse refers to a virtual realm that integrates physical reality with digital environments, enabling users to interact, socialize, and participate in a wide range of activities through the use of avatars and immersive technologies. While there are advantages to adopt the metaverse, the metaverse adoption researches are scarce and primarily focus on the game, education, and sport, providing limited attention to banking services. Furthermore, most adoption research using standard information technology/information system models has focused primarily on organizational context and adopted compulsorily. Metaverse banking service is mainly adopted voluntarily by users and for personal purposes. Thus, this leads to the difficulty in drawing meaningful conclusions toward metaverse adoption. The study addresses these issues by proposing a new unified theory of acceptance and use of the metaverse technology model (UTAUMT), which consists of metaverse performance expectancy (MPE), metaverse facilitating conditions (MFC), metaverse effort expectancy (MEE), and metaverse social influence (MSI) to determine metaverse banking service adoption. Moreover, metaverse trust (MET) and metaverse financial resources (MEF) are also incorporated to investigate complexity in the metaverse environment. The integrated model has been developed and validated through a pretest (face validity and content validity) and pilot test before applying to 491 metaverses-experienced users in Vietnam through a questionnaire approach. Partial least squares structural equation modelling-artificial neural network (PLS-SEM-ANN) has provided a comprehensive result as it can capture both linear and nonlinear relationships. The results from the model showed that only one of the proposed hypotheses between metaverse financial resources (MEF) and behavioural intention to use metaverse banking services (BIM) was not supported in this study and thus needed further investigation. The study contributes to the academic literature by proposing new constructs to assess users' likelihood of adopting metaverse banking services. The result also assists bank managers in understanding metaverse banking adoption and makes them realize the metaverse banking services' growth opportunity to pursue. Given the limited scope of the study focusing solely on Vietnam, it would be advantageous for future research on the cultural variations among users of mobile social commerce to incorporate a comparative analysis across multiple countries, with a particular emphasis on Asian nations.

1. Introduction

Our social interactions have been modified by technological progress. As an extension of real life, the "metaverse" allows users to participate in various social, economic, and recreational activities online. Metaverse is a global concept that is evolving rapidly, and the adoption of virtual and augmented reality technology will play a significant role in shaping its future. Web 2.0—the period of short message service (SMS), web, and mobile—has led us to where we are now in the metaverse where prominent corporations such as Facebook (currently known as Meta), Roblox, and Epic Games (the developer of Fortnite), along with various emerging enterprises, have been allocating resources towards the advancement of virtual reality (VR), augmented reality (AR), and associated technologies in order to construct components of the metaverse [1]. As a result of the integration of interconnected and immersive virtual spaces that combine physical and digital elements, brand experiences across industries and service types will become more distributed and collaborative. The points earned from using one brand or product can be redeemed for discounts or freebies when using another. Bloomberg Intelligence predicts that by 2024, a plethora of new players will join this fight, increasing the industry's size to $800 billion [2]. It is not in the distant future; the metaverse is here and now. It exists now and will develop further.

However, it is essential to highlight that the metaverse is aimed at providing users with enhanced sensory experiences, interaction, and immersion, blurring the boundaries between the physical and digital realms [3]. These technologies have applications in various industries, including gaming, entertainment, education, healthcare, architecture, and more, offering unique opportunities for communication, visualization, training, and exploration [4]. In the context of customer banking services, metaverse can offer unique and immersive experiences ranging from virtual branches, augmented reality account management, virtual financial education, and virtual reality property tours to mixed reality banking applications [5]. These applications help customers navigate through a virtual environment to explore different banking services, interact with virtual tellers or advisors, and perform tasks like transferring funds, paying bills, and managing their accounts with intuitive gestures and visualization [6]. Some traditional banks and financial institutions enter the metaverse banking space to meet rising demand. With almost half of bankers foreseeing customers using augmented reality (AR) and virtual reality (VR) as an alternative channel for transactions by 2030, the financial industry is eagerly exploring this emerging landscape [5]. Pioneering this movement, BNP Paribas has taken a step ahead by launching a VR app that empowers customers to conduct various banking transactions, including account opening, in an immersive virtual environment [7]. In a similar vein, Citi has been experimenting with holographic workstations to enhance financial trading experiences [8]. The largest US bank, JP Morgan, has opened a branch in the Onyx Lounge in Decentraland, a metaverse marketplace for digital assets [9]. KB Bank of South Korea launched a metaverse VR branch with avatars for employees, consumers, and employees can talk directly [10]. These institutions have customer bases, regulatory expertise, and financial resources that can give them an edge. They create metaverse banking services by cooperating with fintech startups to offer innovative products. Innovation, user adoption, security, virtual economy integration, regulatory compliance, and virtual world platform partnerships likely drive metaverse banking competition. The increased attention and growing possibilities associated with virtual reality emphasize the importance of incorporating this technology into existing banking frameworks. Moreover, numerous well-known companies are actively investigating novel business models in which customers acquire nonfungible tokens (NFTs) in the metaverse in addition to the physical goods they purchase. Gartner predicts that by 2026, 25% of people will spend at least an hour per day in the metaverse for financial transaction services, social interactions, education, shopping, and entertainment [11]. This is due to the widespread adoption of virtual worlds. Researching the uptake of banking services within this immersive digital realm is crucial for staying ahead of the curve in the face of the ever-changing metaverse landscape and its potential impact on the financial sector. In Vietnam, the importance of digital transformation in the banking sector is highlighted in the Vietnam Banking Report (2022) by FiinResearch [12], which further supports the need for investigation. It highlights the fact that local banks in Vietnam have prioritized digital transformation as a long-term strategy to better serve their customers, attract new ones, and boost their businesses' productivity. Vietnam emerges as a prime location to investigate and comprehend the implications and opportunities presented by the metaverse for banking services, what with its emphasis on digital transformation and the growing interest in virtual technologies worldwide.

Despite the potential of this new market and related intention and adoption issues, few studies have thus far examined the purchase intention in metaverse stores [13], metaverse adoption in higher education [14], marine conservation [15], mobile retailing [16], medicine [17], and intention to participate in the Facebook metaverse [18], providing a limited understanding on metaverse adoption in banking services. As the metaverse continues evolving, banks must consider leveraging their capabilities to enhance customer experiences, streamline operations, and stay relevant in a digital-first world [3] by examining customers' adoption, regulatory considerations, and technological advancement. The "technology acceptance model (TAM)" and the "unified theory of acceptance and use of technology (UTAUT)" are all well-known and widely used IT/IS models for gaining insight into how new technologies are adopted and put to use. However, the models do have certain restrictions. According to the technology acceptance model (TAM) [19], the two most important factors of system use behaviour are an individual's perception of the system's utility and ease of use. Though TAM's validity has been shown across some mobile research and used to explain several adoption studies, it is impossible to draw significant conclusions from these studies because of their variances. Venkatesh et al. [20] proposed UTAUT and its four central components, which directly influence users' intentions and, in turn, their actions. The adoption of IT is affected by gender, age, and experience, and these factors also affect the notions of performance expectation (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). The concept has been critiqued by Venkatesh et al. [21], who point out that it was primarily built based on workers' technology adoption and relied on organizational circumstances. Different sorts of jobs and the degree of complexity in interactions

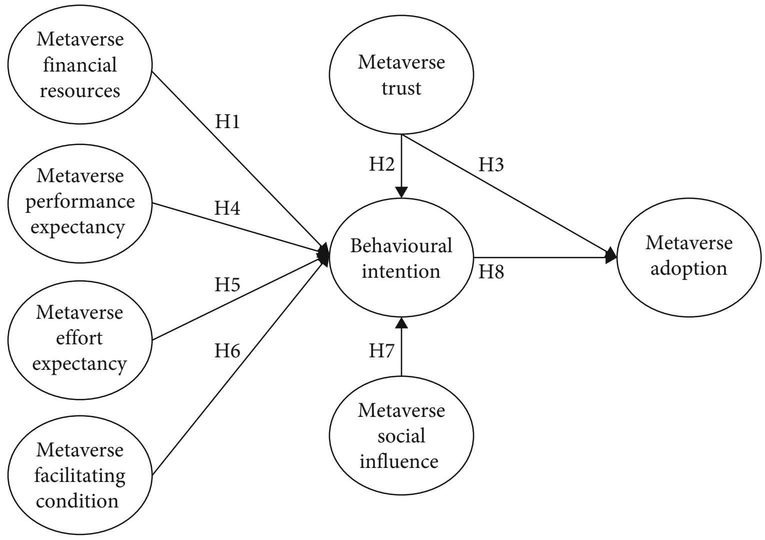

Figure 1: Research model.

are two examples of the many factors influencing the technology adoption rate outside the workplace [22]. Since the new technology has yet to widespread adoption, most customers cannot evaluate it. Hence, neither model is suitable, as Miltgen et al., [23] noted. It is important to note that metaverse adoption is still in its early stages, and the factors from these theories may evolve and change over time as technology and user preferences develop. The success of banking services' metaverse platforms will depend on their ability to meet consumer expectations, provide unique and compelling experiences, and address any barriers or concerns related to trust, accessibility, and affordability. Hence, using the above-mentioned IT/IS models is not suited to be adopted in metaverse adoption studies.

In order to close the research gap, the study proposed a new base model termed as "unified theory of acceptance and use of metaverse technology," which consists of metaverse performance expectancy (MPE), metaverse effort expectancy (MEE), metaverse social influence (MSI), and metaverse facilitating conditions (MFC). These constructs were given priority based on the similarity of PE, EE, SI, and FC in the UTAUT, acknowledging their importance in the study of IT/IS adoptions. In a metaverse environment, consumers' trust, financial resources, and characteristics are equally important in determining the success rate [6]. Hence, the study also proposed two new constructs: metaverse trust (MET) and metaverse financial resources (MEF). The merged framework is an innovative method of understanding metaverse adoption from the customer's point of view instead of the technology used in the metaverse. The study here uses metaverse adoption (MEA) as a proxy and uses behavioural intention (IU) as a measure [20]. According to Leong et al. [24], IU predicts customers' future behaviour. This option makes sense because metaverse in banking service is just starting in its product life cycle and has yet to have much focus thus far. The research provides accurate insights on consumer metaverse adoption by basing such insights on the new integrated framework that pulls together UTAUMT (see Figure 1).

The following summarizes the study. In the beginning, we will give a rundown of the benefits of banking services. We then provide our research framework and conduct a rigorous instrument development and validation process using face and content validity. Next, we go out the research strategy and data analysis. After that, we will talk about what we learned and why it matters for theory and practice in management. Finally, the study wraps up with suggestions for future research and a discussion of the work's limitations.

Two significant contributions can be found in this study. First, we modelled UTAUMT after the characteristics of metaverse users and made it suitable for banking services in a metaverse environment, which has yet to be well represented in previous IT/IS studies. The current model is expected to be a primary resource for research into metaverse technology in the coming years. Second, research on metaverse-specific precursors is still in its infancy. Many researchers have tried to transfer theories from the field of electronic commerce to the field of metaverse studies [13, 25]. As a result of our suggested metaverse constructions, the whole image of metaverse adoption may be seen for the first time. The study's results have substantial management relevance. Marketers may improve their methods to convince customers to embrace banking services in the metaverse if they first learn why certain people are unwilling to do so. This improves the direction for planning an effective metaverse deployment. As a result, the new invention will be more widely disseminated and used.

2. Literature Review and Hypothesis Development

2.1. Metaverse. Though there is no universally accepted description of the metaverse, the typologies developed by the Acceleration Studies Foundation can help organize the many metaverse services and components [26]. The term "metaverse" is a combination of "meta" (meaning beyond) and "universe." It refers to a virtual reality space where users can interact with a computer-generated environment and other users in real-time [27]. The metaverse typically includes immersive experiences, virtual worlds, augmented reality, and virtual reality. Users can explore, create, and engage with various activities and content in the metaverse. It goes beyond traditional online platforms or games by offering a more immersive and interconnected experience. The metaverse has the potential to encompass a wide range of applications, including gaming, social interactions, virtual commerce, education, entertainment, and even virtual banking and financial services [2, 28].

With network and computer technology, artificial intelligence technology, blockchain technology, Internet of Things technology, and video game technology, a virtual community of actual individuals will be developed [28]. While the virtual world allows for innovation, its usefulness is restricted by its disconnection from the actual world [3]. In a virtual world with three dimensions, people's dreams and ideas may come true [28]. Metaverse characteristics include "self," "social," "immersive," "anywhere," "diverse," "economics," and "civilization," as listed by Ning et al. ([29], p.3-p.12,). The goal of merging a permanent virtual environment with a virtual, augmented physical reality is to create a seamless bridge between the virtual and actual worlds [30]. Metaworld may be broken down into two parts: people's need for a better-than-real virtual world and the technology that will bring that world into contact with ours [30]. Combining metaverse technology with banking services, customers can have virtual meetings with financial experts to plan their financial goals, engage with virtual simulations to learn about budgeting, investing, and making financial decisions.

Smart et al. [26] proposed four scenarios where users would benefit from the metaverse's connection to the real world. First, augmented reality is a term for technologies that add digital layers to a user's view of their immediate physical surroundings to make previously inaccessible data and services more easily accessible. Second, lifelogging is a personal and enhanced metaverse platform for documenting and discussing regular people's lives. Mirror worlds, the third type of virtual space, are built on reflections of the real world and provide users with online support for their offline pursuits. Lastly, virtual worlds are online communities in which thousands or even millions of users interact through digital avatars in a simulated environment, complete with their own culture, economy, and government.

2.2. Metaverse Banking Services. Transforming traditional banking into metaverse banking requires a combination of technological adaptation, strategic partnerships, customer education, and a forward-thinking approach [2]. Banks must stay abreast of emerging metaverse trends and continually innovate to meet the evolving needs of users in the virtual environment. Currently, through the Internet and technological advances, customers can access banking services depending on the capabilities offered by their financial institution, such as online banking, mobile banking, virtual banking, and online payment systems [31, 32]. Most customers are more familiar with online and mobile banking than others and are willing to adopt these services [33, 34]. In order to differentiate online banking services, mobile banking services from metaverse banking services, the definitions of these services would be provided to establish a clear understanding of the broader banking landscape and how metaverse fits into it.

To put it simply, online banking services are any service a bank offers its customers that runs on the Internet and can be accessed at any time [35]. The substitution of traditional, paper-based transactions via ebanking services and the provision of instant information and transactions through the bank's website and mobile technologies are examples of what online banking services mean. Additionally, mobile banking refers to providing banking services through mobile devices, such as smartphones and tablets, using dedicated mobile applications or mobile-optimized websites [36]. It allows customers to access and manage their bank accounts, conduct financial transactions, and utilize various banking services conveniently and securely from their mobile devices. Online and mobile banking differ in devices, portability, user experience, features, and security measures [36]. Online banking is accessed through a web browser. In contrast, mobile banking is specifically designed for smartphones and tablets through dedicated mobile apps or mobile-optimized websites [37]. Mobile banking offers greater portability and accessibility, optimized user experience for smaller screens and touch interfaces, and additional mobile-specific features such as mobile check deposits and push notifications [36]. Both online and mobile banking employ security measures, but mobile banking apps may offer additional security features like biometric authentication.

A growing number of these services are being introduced, but an additional promotion by banks is necessary to secure their adoption [32]. The advantages of Internet banking services have also been extensively studied [33]. However, the benefits do not ensure people's willingness to adopt [38]. Therefore, effective marketing of the services is required. Due to the decline in branch banking from clients, especially millennials, online and mobile banking services pose a challenge to traditional banking services [33, 39]. In response to these challenges, established financial institutions may decide to expand their banking offerings and develop innovative digital banking solutions. According to J.P. Morgan [9], those are reasonable steps that conventional banks can take to meet the changing needs of their consumers.

Regarding metaverse banking services, virtual reality goggles are the tool of choice. One of the most critical considerations in determining which banking channel is most appealing is that consumers' experiences will vary depending on their devices, even if those devices access the same online banking services. Although metaverse banking services are still in their early stages, the customer experience is envisioned to be immersive and digitally engaging. In a metaverse banking environment, customers can navigate virtual worlds, interact with avatars, and seamlessly access their financial accounts and services [40]. They may be able to perform transactions, check account balances, transfer funds, and engage in financial activities within the metaverse ecosystem. The experience will likely be highly personalized, with virtual assistants guiding customers through their financial needs and providing real-time support. Metaverse banking has the potential to offer a unique and interactive way for customers to manage their finances, combining the convenience of digital banking with the immersive nature of virtual reality [41]. However, as metaverse banking is an emerging concept, actual customer experiences will evolve as technology advances and financial institutions develop their offerings.

By embracing these cutting-edge technologies, both users and banks will be at the forefront of the digital banking revolution, contributing to the emergence of novel and captivating frameworks in the realm of finance [42]. Consider, for instance, a scenario where an early adopter of metaverse banking is granted privileges and advantages that are unavailable to customers utilizing conventional banking channels. This confers an element of exclusivity and prestige to their online banking experience. Additionally, the sociocultural dimension of the metaverse plays a pivotal role in the acquisition of fresh users [28]. According to Jafar et al. [13], the utilization of the metaverse enables bank customers to establish trust and rapport with their bank representatives through personalized and real-time engagement. An illustration of this type of virtual interaction could involve a customer engaging in a virtual meeting with a customer support representative from a bank to obtain personalized financial guidance and support, consequently enhancing their affinity for and trust in the virtual banking system. The inclusion of digital assets like cryptocurrencies and nonfungible tokens (NFTs) within the metaverse banking ecosystem provides users with additional features and benefits that are not typically accessible through conventional banking channels [3]. Individuals have the capacity to readily participate in cryptocurrency transactions within virtual environments, thereby expanding their access to and familiarity with the potential advantages of decentralized finance (DeFi). The increasing acceptance of online banking among individuals has led to a significant transformation in the financial service industry, characterized by enhanced accessibility, heightened interest, and the adoption of innovative technologies.

This study introduces the concept of metaverse banking services, which pertains to financial services and transactions carried out within the metaverse. The metaverse refers to a virtual reality environment where users engage with computer-generated surroundings and interact with other users. Metaverse banking is an extension of conventional banking services that operates within the virtual domain. It enables users to effectively oversee virtual assets, engage in virtual currency transactions, and actively participate in the virtual economy. Furthermore, it is imperative to distinguish between the different banking channels, namely, online banking, mobile banking, and automated teller machine (ATM) usage. The inclusion of metaverse banking within the broader category of other banking channels may result in client confusion, as the unique essence of metaverse banking is not adequately captured by these other channels. Hence, the elucidation of metaverse banking service will facilitate the incorporation of metaverse banking as a novel banking channel, streamlining the organization of diverse banking alternatives accessible to customers by financial institutions. The dependent variable will be the adoption of banking services in the metaverse. The notion of the metaverse is a relatively nascent concept within the population of developing nations, such as Vietnam. Nevertheless, owing to significant advancements in this technology, banking institutions in Vietnam have come to a collective consensus that the metaverse will serve as a pivotal element for the future of banking [12].

2.3. UTAUT. According to the proposal of Venkatesh et al. [20], UTAUT combines eight established models with improved prediction ability. Perceived usefulness [19], relative advantage [43], extrinsic motivation [44], work fit [45], and outcome expectations [46] all lend credence to performance expectancy in UTAUT. Performance expectancy refers to the extent to which the user thinks the technology aids in performance enhancement [20]. Ease of use [19], complexity [45], and ease of use [43] are all factors that contribute to a user's effort expectancy. The user's perception of the technology's usability [20], image [43], the subjective norm [47], and social influences [45] all lend credence to the concept of social impact, which means how significant others to the user agree that the user should use the technology [20]. Compatibility [43], perceived behavioural control [48], and the facilitating conditions [45] are all incorporated into the facilitating conditions to construct user perceptions about the availability of appropriate organizational and technical support for a specific technology [20].

There are three main types of in-depth studies on UTAU T: (1) to put UTAUT to the test in novel settings [49]; (2) including additional constructs in UTAUT to broaden its applicability [21, 50]; and (3) including predicate information in UTAUT constructions [51, 52]. However, Venkatesh, Thong, and Xu [21] expressed reservations regarding the theoretical underpinnings of the model within organizational settings, with a particular emphasis on the acceptance of technology by employees. The adoption of technology in nonwork settings demonstrates unique attributes across multiple dimensions, including the nature of tasks and the level of complexity in interactions [22, 53]. The UTAUT framework has certain limitations in fully explaining the adoption of metaverse scenarios, such as metaverse banking services. This is because the potential adopters of these services include actual consumers of banking services, whose decisions are primarily influenced by personal contexts rather than being solely driven by technology. The "unified theory of acceptance and use of metaverse technology" (UTAMT) uses a few key concepts to look at how consumers adopt banking services in the metaverse. The first construct, metaverse performance expectancy (MPE), is about what consumers think will happen when they use banking services in the metaverse and what they think the benefits will be. This concept is like the traditional "performance expectancy" (PE) concept from the original UTAUT. Metaverse effort expectancy (MEE) is the second construct. It looks at how consumers feel about how easy and simple it is to use banking services in the metaverse. Similar to the "effort expectancy" (EE) construct in UTAUT, MEE looks at how much effort consumers think they will have to put in to use metaverse-based banking services. Metaverse social influence (MSI), the third construct, looks at how social factors affect consumers' plans to use metaverse banking services. This concept reminds me of the "social influence" (SI) concept in UTAUT, which focuses on how social interactions and norms affect decisions about when and how to use new technology. Metaverse facilitating conditions (MFC) is the fourth construct. It includes the availability of resources and support that help people use metaverse banking services well. This is similar to the "facilitating conditions" (FC) construct in UTAUT, which shows how important it is for outside factors to make it easier for people to use technology. The study also takes into account the impact of consumers' individual traits and introduces two new critical factors, namely, metaverse trust (MET) and metaverse financial resources (MEF). The six concepts are brought together in UTAUMT to provide a fresh perspective on the drivers of metaverse adoption in banking services, one that moves the conversation away from a focus on technology to one that prioritizes the needs of end users.

As the metaverse undergoes further development, it becomes imperative for financial institutions to effectively utilize its capabilities in order to improve customer experiences, streamline operations, and remain pertinent within a progressively digital environment. In order to accomplish these objectives, it is imperative to conduct a comprehensive analysis of customer adoption trends, regulatory ramifications, and technological progressions. The "unified theory of acceptance and use of metaverse technology" (UTAUMT) presents a new perspective for examining the adoption of banking services by consumers in the metaverse.

2.4. Hypotheses Development

2.4.1. Metaverse Financial Resources (MEF). The metaverse financing resources (MEF) for using metaverse banking services (such as equipment cost, transaction fees, and bank-specific charges) refer to the extent to which an individual compromises regarding possessing the financial resources to utilize metaverse banking services. Ooi and Tan [53] noted that people's inability to afford innovations is a common barrier to their widespread adoption. In general, in the metaverse, personal computers, smartphones, head-mounted displays, sensors like sensory gloves, and other input devices are all necessary for extended reality (XR) hardware and software applications to function correctly and provide an immersive experience [54]. While the required technology can pose challenges, it is essential to note that technology is continuously evolving, becoming more accessible, affordable, and user-friendly. As the metaverse and related technologies advance, we expect improvements in device affordability, network infrastructure, and user interfaces, which can help bridge the gap and enable broader adoption of metaverse banking services. Consumers with limited or restricted financial resources may find metaverse adoption prohibitive due to the expensive cost of the technology. As a result, the adoption would provide fewer real-world benefits and be more challenging to utilize. Based on the research of [24, 55], they recommend implementing innovative pricing and marketing strategies to encourage more customers to use innovative technology. In terms of banking services in the metaverse, if banks can either invest in reducing the cost of accessing metaverse technologies, such as virtual reality (VR) or augmented reality (AR) devices, making them more accessible to a broader range of consumers or provide financial support or subsidies, consumers will have a perception that using banking services in the metaverse is affordable, and they will have the intention to use it. This argument leads to the following hypothesis:

Hypothesis 1. Metaverse financing resources have a positive and significant relationship with the intention to use banking services in the metaverse.

2.4.2. Metaverse Trust (MET). When people talk about "trust," they refer to the underlying belief that others will be honest and deliver on their commitments. Customers are more inclined to participate in banking service transactions in the metaverse if banks demonstrate kindness, integrity, and expertise [56]. It is more challenging for a bank to establish trust in the metaverse of banking services, just as in traditional banking. The metaverse introduces new dimensions and challenges to trust perception, involving virtual environments and digital interactions. As a result, MET is crucial in the virtual world. Otherwise, trust cannot be built, and relationships cannot last. However, the metaverse can provide banks with new avenues to engage with their customers in immersive and interactive ways, which is totally different from online financial services that lack personal interaction between the buyer and seller. Furthermore, existing and emerging threats to users' security and privacy are posed by the wide range of vulnerabilities in the many components that make up this technology [57]. Timely detection is a big worry of hi-tech enterprises and government agencies [58] since risks involving XR data breaches can be particularly stealthy because they do not require users' involvement. To function, stay in sync, and deliver seamless consumer experiences, XR devices and applications must ensure the availability and security of data at rest and in transit. Possible financial damages could result from the loss of confidential financial information. Potential security breaches lead to unauthorized access to user accounts or theft of virtual assets within the metaverse [59]. It is crucial for banks and metaverse service providers to proactively assess and mitigate security and privacy risks through robust security measures, user education, and regulatory compliance. XR's potential dangers and weaknesses necessitate the creation of protective measures from banks to encourage appropriate design, development, and safeguards [60]. Previous studies have shown that trust can improve consumers' likelihood of using the new technology [61]. Similar The beneficial effects of MPT and IU were also corroborated by the research of [62]. They concluded that consumers would only use the new technology if their personal information was protected against fraud and identity theft. It has been hypothesized as follows:

Hypothesis 2. Metaverse trust has a positive and significant relationship with the intention to use banking services in the metaverse.

Hypothesis 3. Metaverse trust has a positive and significant relationship with the adoption of the use of banking services in the metaverse.

2.4.3. Metaverse Performance Expectancy (MPE). Similar to the usefulness sub-constructs of relative advantage and extrinsic motivation, MPE describes how these factors contribute to an individual's enhanced performance on the job [20]. Likewise, in this research, MPE refers to individuals' confidence levels in the efficacy of various technological aids when adopting banking services in the metaverse. Metaverse banking services can leverage customers' data and preferences to offer personalized and customized experiences. Virtual environments can be tailored to customers, displaying relevant financial information, personalized recommendations, or financial planning tools. This level of personalization enhances customer engagement and satisfaction, leading to a positive performance expectancy. Thus, the following hypothesis has been constructed:

Hypothesis 4. Metaverse performance expectancy has a positive and significant relationship with the intention to use banking services in the metaverse.

2.4.4. Metaverse Effort Expectancy (MEE). According to the definition provided by [20], MEE is synonymous with the degree of difficulty in using a given IT/IS. Therefore, MEE incorporates the concepts above and denotes the perceived difficulty to learn and use when adopting metaverse banking services by prospective adopters. The metaverse needs far more time and energy to understand and implement than traditional banking systems. However, metaverse banking services can automate and streamline various banking processes, eliminating manual steps and paperwork. For example, account openings, loan applications, or fund transfers can be simplified and expedited within the metaverse environment. This reduces the effort required to complete these tasks, making banking activities more efficient and convenient for customers. Potential adopters form positive opinions as a result. Effort anticipation is one of the most significant elements in technology acceptance, as the available literature shows [56, 63–65]. The greater the convenience of metaverse banking service systems, the more likely users will adopt them. This led us to the following hypothesis:

Hypothesis 5. Metaverse effort expectancy has a positive and significant relationship with the intention to use banking services in the metaverse.

2.4.5. Metaverse Facilitating Condition (MFC). Metaverse facilitating condition (MFC) is similar to facilitating that Venkatesh et al. [20] defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" (p. 453). In this study, MFC describes how well a metaverse technology innovation may align with its prospective users' expectations, preferences, values, and routines through the use of metaverse banking services with the support and bank and service providers. Using banking services in the metaverse is common. Consumers are already adopting online service banking in their daily lives. However, positive experiences with current types of technology can be more easily transferred to future technologies if they are more similar and suit similar needs. As metaverse is based on mobile devices and personal computers, consumers are more receptive to adopting if they have experience using these devices and receive support from banks if a technical issue arises. In the IS/IT literature, MFC was found to positively influence the adoption of new technology [66]. Thus, it is reasonable to assume that if the metaverse in banking services is designed to facilitate consumer use, this would lead to the perception that using banking services in the metaverse is supported and then meet customers' exceptional experience. Therefore, we hypothesize that

Hypothesis 6. Metaverse facilitating condition has a positive and significant relationship with the intention to use banking services in the metaverse.

2.4.6. Metaverse Social Influence (MSI). When the views of others influence people's decisions to use technology, we say that they are subject to social influence (SI) [20]. The subjective norm in TAM2 and the social norms in TRA are examples of social influence. Predicting the uptake of new technology is difficult, but SI is expected to be the most crucial factor. Positive recommendations or endorsements from friends, family, or colleagues can influence an individual's decision to use metaverse banking services. When individuals observe others within their social circle using and benefiting from these services, they may be more inclined to try them out themselves. Moreover, social media platforms and online communities dedicated to metaverse or financial discussions can shape individuals' perceptions and influence their adoption decisions. Participating in online discussions, reading reviews, or engaging with user-generated content can expose individuals to different perspectives, experiences, and recommendations related to metaverse banking services. These interactions can influence their attitudes and adoption intentions. Existing research on technological adoption shows that social influence benefits people's propensity to use the technology [63–65]. Consequently, the following was our working hypothesis:

Hypothesis 7. Metaverse social influence has a positive and significant relationship with the intention to use banking services in the metaverse.

2.4.7. Behavioural Intention to Use Metaverse Banking Services (BIM). The adoption behaviour of a person is defined as the manifest, observable response in a given situation concerning a given target [67]. Similar to the definition of Ajzen [67], the adoption of metaverse banking services refers to the process by which individuals or customers begin using and incorporating virtual or augmented reality-based banking services within the metaverse into their financial activities. It involves accepting, utilizing, and integrating these services into customers' banking behaviours and routines. Adoption signifies a customer's willingness to engage with and leverage metaverse banking services for various financial transactions, interactions, and experiences. Customers' attitudes toward technology, including familiarity, comfort, and positive perceptions, influence their intention to adopt metaverse banking services. Individuals who have a positive attitude toward technology and are open to embracing innovations are more likely to develop a positive intention to adopt metaverse banking services. If customers find value in these services and continue to leverage them for their ongoing financial needs, indicating a successful adoption process. Several studies have shown a correlation between BI and UB in IT acceptance research [68, 69].

Hypothesis 8. Behavioral intention has a positive effect on the adoption of banking services in the metaverse.

3. Methodology

3.1. Instrument Development and Validation. The research utilized a rigorous methodology that included multiple essential stages in order to establish the validity and reliability of the measurement instrument. The research began by conducting a thorough review of existing literature to gain a comprehensive understanding of the field of metaverse banking adoption. The identification and definition of key constructs, such as metaverse performance expectancy (MPE), metaverse effort expectancy (MEE), metaverse social influence (MSI), metaverse facilitating conditions (MFC), metaverse trust (MET), and metaverse financial resources (MEF), were influenced by this. The selection of existing items from pertinent literature was conducted by considering the definitions of these constructs. The chosen items underwent additional refinement and were adjusted to suit the specific circumstances surrounding the adoption of metaverse banking. Following this, operational definitions were formulated using these modified items in order to establish a consistent and harmonized measurement methodology.

In order to establish the validity of the measurement instrument, a preliminary assessment was undertaken, which entailed a comprehensive evaluation by a panel of experts to ascertain both the face and content validity. The instrument was subjected to a rigorous evaluation by an expert panel consisting of no fewer than six experts, who conducted a thorough analysis and offered valuable perspectives. The instrument underwent revisions in response to expert feedback in order to improve its clarity, relevance, and comprehensiveness. The quantitative assessment of the validity of each item was conducted using the item content validity index (I-CVI), with a minimum criterion of 0.83. Additionally, the scale-level content validity index (S-CVI/AVE) was used to assess the overall content validity of the scale, with a minimum criterion of 0.90. Any items or scales that did not meet these criteria were excluded from the instrument.

Subsequently, the pilot testing phase was conducted, wherein prospective participants offered their feedback regarding the clarity and relevance of the instrument. The instrument underwent refinement in response to the feedback received, with the aim of enhancing its comprehensibility and aligning it more closely with the perspective of the respondents. In addition, the internal consistency of the instrument was evaluated through the utilization of Cronbach's alpha coefficient. Items that did not make a substantial contribution to optimizing the alpha value were subsequently removed.

After completing the validation stages, the instrument was made ready for fieldwork testing. This involved assessing the presence of common method bias (CMB) and ensuring its overall validity. By engaging in a process of iterative refinement and conducting rigorous testing, the study was able to establish that the measurement instrument successfully captured the intricate aspects of metaverse banking adoption. This approach contributed to the overall robustness of the instrument's subsequent application and analysis.

According to Nunnally [70], an effective instrument must be able to cover the content domain of every construct in order for it to be built. Items that are used to measure a construct need to group, whereas items that are used to measure a construct must differentiate themselves from items used to measure other constructs. Every single build has to be trustworthy and solid.

3.2. Measurement Scales. Because they can provide a more considerable degree of dispersion while also decreasing the number of neutral answers, 7-point Likert scales were used in this investigation to quantify the amount of agreement to a specific statement. For a scale that measures levels of agreement, the responses range from (1) strong disagreement to (7) strong agreement.

3.3. Operational Definitions. The operational definitions of each construct used in this investigation are mentioned in the hypothesis sections. Appendix A is a listing of the measuring scales, sources for adaption, and used for fieldwork after the development and validation process.

3.4. Target Population, Sample, and Data Collection Procedures. Users in Vietnam with prior experience in the metaverse will serve as respondents for this research. Bain and Co. and Meta's study indicated that 74% of Vietnamese internet users had used some metaverse technology in the last year, whether in cryptocurrency, augmented reality, virtual reality, a networked fantasy world, or a nonfungible token (NFT) (Ngoc [71]). Deloitte predicts that in 2035, the metaverse might be responsible for $9-17 billion in annual economic effects in Vietnam (Ngoc [71]). Critical industries like gaming and education are poised for rapid growth. Up five spots from 2021, Vietnam now sits at #54 on StartupBlink's Global Startup Ecosystem Index 2022 [71]. This quantitative investigation used an online Google survey to collect data in public and private universities with faculty and blockchain summit or events hosted in Ho Chi Minh City. Respondents were chosen using a judgmental convenience sampling method. The utilization of judgmental convenience sampling is deemed appropriate for this study for two main reasons. Firstly, there is a lack of a sampling frame available for banking service users. Secondly, there is a need to gather specific information that is exclusively relevant to a particular group, namely, individuals who have prior experience with metaverse technology [72]. Participants were assured that their anonymity would be protected and that their data would be utilized only for academic analysis. They were also told they were not obligated to participate in the study if they did not want to. The questionnaire was sent out in English only because most fintech-related courses and blockchain summits are taught and delivered in English. The average time it took respondents to complete the survey was seven to ten minutes. The minimum sample size required for the study was determined using G*Power software (version 3.1.9.2). The parameters were set to include a power level of 0.80, an alpha value of 0.05, an effect size of 0.15, and 7 predictors. The analysis indicated that a minimum of 103 participants would be necessary. Four hundred ninety-one valid replies were obtained, providing the empirical data necessary to validate the constructed conceptual model and examine the proposed hypotheses.

3.5. Pretest. In the stage before the pretest, measurement scales were constructed based on the instrument's content and face validity. These include evaluations conducted by an expert panel and practitioners, which are used to evaluate the face validity and content validity index (CVI).

3.6. Scale Development and Expert Panel. An extensive assessment of the relevant literature was used to adjust the scales used in the instrument from those used in previous studies. After that, an expert panel made up of three academics working in information systems (IS) who are either the editor-in-chief or guest editor of information systems-related journals and have published a large number of ISI/Scopus-ranked journal articles evaluated the face validity and content validity of these scales. As a result, they can make appropriate suggestions based on their knowledge. The other three expert panel members are seasoned professionals with extensive professional experience in metaverse settings.

3.7. Face Validity. Face validity differs from content validity in that it refers to the condition when items ought to imply what they are meant to measure. In contrast, content validity refers to the condition that items should represent an appropriate sample of the construct's domain [73]. It was decided to use an expert panel to guarantee the instrument's seeming validity. The members of this panel were responsible for determining whether or not the measures included within the instrument measure what they are believed to measure. The expert panel provided the members with comments, and based on that feedback, the members were largely happy with the instrument's face validity. However, the members did advise some minor adjustments and formatting changes to the instrument.

3.8. Content Validity. Content validity is an essential need for a good and trustworthy measure. In order to ensure that the items accurately represent the construct being measured (i.e., their "content validity"), it is common practice to use previously published measurement items for the construct and to conduct an item-by-item review by practitioners and experts prior to and following the pilot test [73]. The content validity index (CVI) is the gold standard for assessing content validity [74]. Both item-level CVIs (I-CVIs) and scale-level CVIs (S-CVIs) were analyzed. Customarily, a neutral middle ground is avoided using a 4-point ordinal scale. On this scale, "not relevant" is the lowest possible score, and "highly relevant" is the most. Relevant things have a rating of 3 or 4, whereas those with lower ratings (1 or 2) are disregarded.

3.8.1. Item-Level CVI. The percentage of experts in the panel who rate something as a 3 or 4 (thus dividing the ordinal scale in half, relevant and not relevant) is used to determine the I-CVI. Lynn [74] suggested using a minimum I-CVI of 0.83 when using a panel of six experts. Table 1 displays the expert panel evaluations' effects on the I-CVIs of the instrument's components. We found that all items had appropriate content validity since all I-CVIs are at least 0.83; hence, no items were removed from the instrument.

3.8.2. Scale-Level CVI. The S-CVI is the percentage of things scored as a three or four by both raters. The S-CVI may be universally agreed upon (S-CVI/UA) or calculated using an average value (S-CVI/AVE). When comparing S-CVI/UA and S-CVI/Ave, the former measures the average percentage of things rated 3 or 4 by the panel experts, while the latter measures the proportion of items rated 3 or 4 by the experts. S-CVI/AVE is preferred over SCVI/UA because the former is too strict if there are numerous experts, while the latter is too conservative if there is 100% agreement [75]. Therefore, we settled on S-CVI/Ave as the accepted criterion for scale content validity. S-CVI/Ave should be at least 0.90, as suggested by Lynn [74]. Table 1 shows that all SCVIs are more than 0.90, indicating that all scales have sufficient content validity and that no scales were removed from the instrument.

3.9. Pilot Test. A subset of metaverse users from a metaverse-related group on Facebook was recruited to participate in a pilot test of the instrument before it was used in the primary survey. Choosing the sample size for the pilot test is unnecessary based on statistics [76]. According to Wilcox et al. [77], the number of respondents in a pilot test that ranges from 20 to 50 is sufficient for discovering questionnaire problems. Considering this, we interviewed one hundred people for our study. Fifty-five of them were valid samples. The construct reliability and clarity of the instrument will be evaluated as part of the pilot test; this will be the test's primary purpose. Before the instrument was eventually ready to be used in the fieldwork research, it underwent some minor alterations and amendments to be used in the pilot test study

Table 1: I-CVI and S-CVI analysis.

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Agreement	I-CVI	S-CVI/Ave
Metaverse effort expectancy (MEE)									
MEE1	x	x	x	x	x	x	5	0.83	1.00
MEE2	x	x	x	x	x	x	6	1.00	
MEE3	x	x	x	x	x	x	5	0.83	
MEE4	x	x	x	x	x	x	6	1.00	
Proportion relevant	1.00	1.00	1.00	1.00	1.00	1.00			
Metaverse performance expectancy (MPE)									
MPE1	x	x	x		x	x	5	0.83	0.92
MPE2	x		x	x	x	x	5	0.83	
MPE3	x	x	x	x	x	x	6	1.00	
MPE4	x	x	x	x	x	x	6	1.00	
Proportion relevant	1.00	0.75	1.00	0.75	1.00	1.00			
Metaverse social influence (MSI)									
MSI1	x	x	x	x	x	x	6	1.00	0.92
MSI2	x	x	x	x	x	x	6	1.00	
MSI3	x	x		x	x	x	5	0.83	
MSI4		x	x	x	x	x	5	0.83	
MSI5	x	x	x	x	x		5	0.83	
Proportion relevant	0.80	1.00	0.85	1.00	1.00	0.85			
Metaverse facilitating condition (MFC)									
MFC1	x	x	x	x	x	x	6	1.00	1.00
MFC2	x	x	x	x	x	x	6	1.00	
MFC3	x	x	x	x	x	x	6	1.00	
Proportion relevant	1.00	1.00	1.00	1.00	1.00				
Metaverse trust (MET)									
MET1	x	x	x	x	x	x	6	1.00	0.92
MET2		x	x	x	x	x	4	0.83	
MET3	x	x	x	x	x	x	6	1.00	
MET4	x		x	x	x	x	5	0.83	
Proportion relevant	0.75	0.75	1.00	1.00	1.00	1.00			
Metaverse financial resources (MEF)									
MEF1	x	x	x	x	x	x	6	1.00	1.00
MEF2	x	x	x	x	x	x	6	1.00	
MEF3	x	x	x	x	x	x	6	1.00	
Proportion relevant	1.00	1.00	1.00	1.00	1.00	1.00			
Behavioral intention to use metaverse banking service (BIM)									
BIM1	x	x	x	x	x	x	5	0.83	0.90
BIM2	x		x	x	x	x	5	0.83	
BIM3	x	x		x	x	x	5	0.83	
BIM4	x	x	x	x	x	x	6	1.00	
BIM5	x	x	x	x		x	5	0.83	
Proportion relevant	1.00	0.80	0.80	1.00	0.80	1.00			

Table 1: Continued.

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Agreement	I-CVI	S-CVI/Ave
Metaverse banking services adoption (MEA)									
MEA1	x		x	x	x	x	5	0.83	0.90
MEA2	x	x	x	x	x	x	5	0.83	
MEA3		x	x	x	x	x	5	0.83	
MEA4	x	x	x	x	x	x		1.00	
MEA5	x	x		x	x	x	5	0.83	
Proportion relevant	0.80	0.80	0.80	1.00	1.00	1.00			

Table 2: Demographic profile of respondents.

Items		Frequency	Percent
Gender	Male	311	63.34%
	Female	180	36.66%
Age	18-25	195	39.71%
	26-34	128	26.07%
	35-45	145	29.53%
	Above 45	23	4.68%
Highest education level	Bachelor's degree	235	47.86%
	Master's degree	180	36.66%
	Ph.D. degree	76	15.48%
Experiences in the metaverse field	Less than 6 months	136	27.70%
	From 7 months to 1 year	180	36.66%
	More than 1 year	175	35.64%
Do you prefer to use metaverse in your daily life?	Yes	325	66.19%
	No	166	33.81%

first. These comments and feedback were considered while the instrument was being developed.

We conducted a reliability test on the constructs using SPSS version 25 and got Cronbach's alpha for each. Items that did not contribute to the alpha value were eliminated via a process that included many iterations. Since all preliminary alpha values (0.705-0.965) surpassed the threshold of 0.70 [78], we concluded that the instrument possesses a high level of construct validity.

3.10. Statistical Analyses after Fieldwork. The partial Least Square-Structural Equation Modelling-Artificial Neural Network (PLS-SEM-ANN) method was used to evaluate the study model shown in Figure 1. In the Artificial Neural Network (ANN) study, the input neuron was the critical determinant discovered in the PLS analysis. For the PLS-ANN method, PLS is recommended over SEM for three reasons. To begin, PLS may be used even if the sample size is small since it does not need proof of normality [79]. Second, PLS works well for assessing complex prediction models [51]. As a third benefit, PLS may examine the structural and measurement models concurrently [80–82]. Therefore, PLS may provide more statistical power than SEM. As a result, the two-stage PLS-ANN technique will be used for preliminary analysis rather than the SEM. In addition, there were two motivations for using a two-stage PLS-ANN technique. First, PLS is limited in its ability to uncover nonlinear correlations since it is a variance-based SEM analysis [65]. We discovered that MET, MEE, MPE, MSI, and MFC did not have linear correlations with BIM using an analysis of variance (ANOVA) nonlinearity test [83, 84]. The ANN analysis, which can identify linear and nonlinear connections, compensates for this shortcoming [85]. Second, although ANN may identify nonlinear and linear correlations [86], its "black box" operation is inappropriate for parametric hypothesis testing. Since testing the hypothesis and identifying linear and nonlinear interactions in the research model are mutually beneficial, we have used a combined PLS-ANN technique. Both the reliability and validity of the outside measurement model and the inside structural model were initially evaluated. Lim et al. [87] agree with this strategy, which they call a "two-step approach."

4. Results and Discussion

4.1. Demographic Profile of Respondents. This survey got 491 Vietnamese user replies. Table 2 describes participation. 63.34% of respondents were male ($N = 311$), while the

Table 3: Measurement model results.

Constructs	Items	Loadings	Cronbach's alpha	Composite reliability (Rho_A)	Average variance extracted (AVE)
BIM	BIM1	0.769	0.875	0.876	0.667
	BIM2	0.835			
	BIM3	0.814			
	BIM4	0.843			
	BIM5	0.821			
MEA	MEA1	0.833	0.876	0.877	0.730
	MEA2	0.867			
	MEA3	0.858			
	MEA4	0.858			
MEE	MEE1	0.849	0.832	0.838	0.665
	MEE2	0.799			
	MEE3	0.819			
	MEE4	0.794			
MEF	MEF1	0.841	0.852	0.856	0.693
	MEF2	0.826			
	MEF3	0.837			
	MEF4	0.826			
MET	MET1	0.837	0.848	0.849	0.687
	MET2	0.832			
	MET3	0.851			
	MET4	0.793			
MFC	MFC1	0.820	0.803	0.805	0.717
	MFC2	0.853			
	MFC3	0.866			
MPE	MPE1	0.826	0.856	0.857	0.698
	MPE2	0.868			
	MPE3	0.826			
	MPE4	0.821			
MSI	MSI1	0.793	0.850	0.855	0.717
	MSI2	0.714			
	MSI3	0.786			
	MSI4	0.821			
	MSI5	0.836			

remainder were female ($N = 180$). Respondents' ages were also 39.71% are 18–25, 26.07% are 26–34, 29.53% are 35-45, and 4.68% are above 27. 47.86% of respondents have bachelor's degrees, 36.66% have master's degree, followed by those who have a Ph.D. degree. 66.19% of participants preferred to use metaverse in their daily lives, while the rest do not.

4.2. Common Method Bias (CMB). Previous studies [79, 88] have proposed a combination of procedural and statistical measures to mitigate the potential common method bias that may arise from collecting data from a single source. In terms of procedure, measures were taken to ensure the anonymity of respondents, and responses were treated in an impartial manner without being classified as either true or false. This approach is aimed at fostering open and honest responses to all inquiries. Harman's single-factor analysis was conducted from a statistical standpoint. Harman's single-factor with eight constructs (MFC, MSI, MPE, MEF, MET, MEE, BIM, and MEA) was used to check for common method bias (CMB) [89]. The eight structures were factored. The most significant variable explained by the single component was 39.65%, below the required 50% [89]. Thus, CMB data is unconcerned.

4.3. Measurement Model Assessment. The measuring model for a reflective model can only be utilized by first ensuring its reliability and validity. Cronbach's alpha and composite reliability (Rho_A) may be used to evaluate reliability, while convergent and discriminant validity can be used to examine the validity of a model. Table 3 shows that Cronbach's alpha

Table 4: Indicator loadings and cross-loadings.

	BIM	MEA	MEE	MEF	MET	MFC	MPE	MSI
BIM1	**0.769**	0.571	0.671	0.587	0.652	0.639	0.569	0.675
BIM2	**0.835**	0.635	0.660	0.574	0.644	0.632	0.574	0.672
BIM3	**0.814**	0.583	0.654	0.579	0.650	0.606	0.581	0.673
BIM4	**0.843**	0.649	0.646	0.572	0.685	0.626	0.621	0.654
BIM5	**0.821**	0.674	0.717	0.651	0.744	0.678	0.673	0.694
MEA1	0.653	**0.833**	0.579	0.576	0.608	0.613	0.608	0.601
MEA2	0.678	**0.867**	0.696	0.616	0.647	0.639	0.689	0.640
MEA3	0.638	**0.858**	0.651	0.585	0.647	0.597	0.631	0.624
MEA4	0.641	**0.858**	0.636	0.585	0.653	0.598	0.627	0.575
MEE1	0.734	0.664	**0.849**	0.674	0.694	0.681	0.676	0.689
MEE2	0.605	0.577	**0.799**	0.704	0.664	0.648	0.620	0.639
MEE3	0.702	0.624	**0.819**	0.619	0.649	0.625	0.641	0.665
MEE4	0.624	0.576	**0.794**	0.646	0.686	0.607	0.587	0.635
MEF1	0.675	0.649	0.730	**0.841**	0.652	0.673	0.652	0.640
MEF2	0.580	0.529	0.632	**0.826**	0.651	0.569	0.598	0.621
MEF3	0.562	0.531	0.650	**0.837**	0.628	0.560	0.573	0.615
MEF4	0.590	0.580	0.668	**0.826**	0.656	0.623	0.587	0.615
MET1	0.697	0.646	0.682	0.657	**0.837**	0.671	0.606	0.711
MET2	0.675	0.631	0.687	0.691	**0.832**	0.636	0.618	0.680
MET3	0.712	0.625	0.693	0.640	**0.851**	0.656	0.595	0.693
MET4	0.660	0.574	0.671	0.586	**0.793**	0.605	0.593	0.596
MFC1	0.627	0.597	0.654	0.634	0.651	**0.820**	0.599	0.681
MFC2	0.661	0.604	0.676	0.596	0.660	**0.853**	0.601	0.666
MFC3	0.691	0.619	0.665	0.631	0.660	**0.866**	0.603	0.691
MPE1	0.603	0.553	0.592	0.509	0.548	0.544	**0.826**	0.544
MPE2	0.648	0.635	0.661	0.630	0.624	0.608	**0.868**	0.604
MPE3	0.589	0.632	0.676	0.642	0.609	0.571	**0.826**	0.590
MPE4	0.633	0.679	0.662	0.644	0.649	0.644	**0.821**	0.634
MSI1	0.663	0.596	0.670	0.609	0.644	0.643	0.560	**0.793**
MSI2	0.547	0.522	0.612	0.613	0.589	0.583	0.536	**0.714**
MSI3	0.655	0.537	0.614	0.565	0.598	0.610	0.563	**0.786**
MSI4	0.691	0.559	0.625	0.576	0.670	0.657	0.564	**0.821**
MSI5	0.694	0.608	0.672	0.611	0.698	0.676	0.589	**0.836**

Note: figures in bold denote significance ($P < 0.05$).

values ranged from 0.803 to 0.876, all over the 0.7 criteria for internal consistency dependability. The composite reliability (Rho_A) values varied from 0.805 to 0.877, more significant than the required 0.7. Thus, Cronbach's alpha and CR indicate that the model's reliability has been established. Convergent validity measures comparable items. To verify convergent validity, factor loadings and AVE were examined [63]. Table 3 shows that all factor loadings exceeded the value of 0.7, meeting the requirements. Table 3 shows that all AVE values were higher than 0.5. Besides, we have discriminant validity evidence when the loadings of each indicator on its construct are higher than the cross-loadings of other constructs [90]. This study uses cross-loading to examine discriminant validity based on the prior assumptions. Table 4 shows that the indicators are loaded highly on their respective constructs. This proves discriminant validity.

4.4. Structural Model Assessment. After establishing the validity and reliability of the construct assessments, we assessed the estimated and saturated models' fitness using the standardized root mean square residual (SRMR). The reported SRMR values (0.048 and 0.073) are less than 0.08, suggesting a satisfactory model fit [91]. The presence of strongly connected components was checked using the collinearity test before diving into the inner structural model. All constructions' VIFs ranged from 1.610 to 2.367, below the threshold value of 5.071 and indicative of a lower risk of multicollinearity [80, 81].

To evaluate and confirm the proposed model's explanatory capacity, we used the popular statistical program SmartPLS 4.0 to analyze endogenous components' structure path coefficients and R square values. The bootstrapping method, innovative in the statistical area, was also used to

Table 5: Results of hypotheses testing.

Hypotheses	Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	2.50%	97.50%	Remark
H1	MEF ⟶ BIM	-0.054	-0.050	0.058	0.944	0.345	-0.164	0.060	Not supported
H2	MET ⟶ BIM	0.285	0.281	0.054	5.269	0.000	0.175	0.385	Supported
H3	MET ⟶ MEA	0.367	0.367	0.060	6.152	0.000	0.246	0.480	Supported
H4	MPE ⟶ BIM	0.124	0.127	0.049	2.502	0.012	0.023	0.220	Supported
H5	MEE ⟶ BIM	0.219	0.219	0.072	3.027	0.002	0.075	0.358	Supported
H6	MFC ⟶ BIM	0.119	0.120	0.055	2.147	0.032	0.008	0.221	Supported
H7	MSI ⟶ BIM	0.275	0.271	0.080	3.434	0.001	0.125	0.432	Supported
H8	BIM ⟶ MEA	0.460	0.460	0.058	7.972	0.000	0.345	0.569	Supported

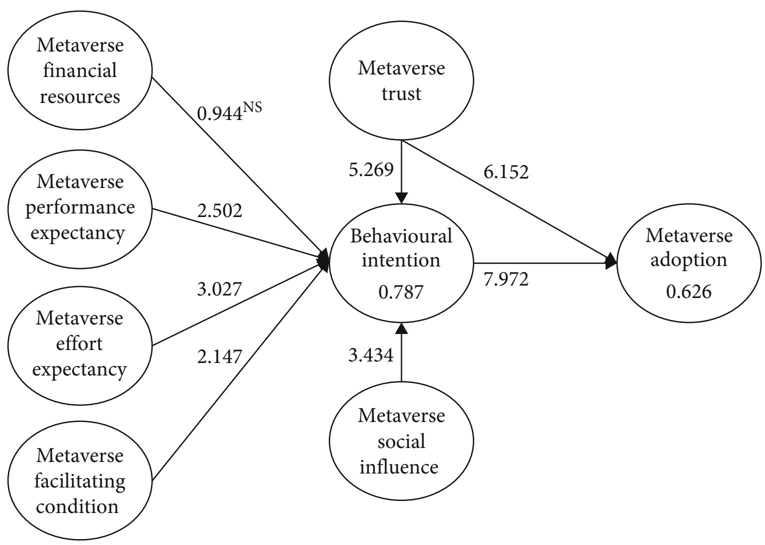

Figure 2: Results of hypothesis testing.

verify the predictions. Such significance was extracted by running with 5000 samples and no sign changes. All hypotheses are supported except for hypothesis 1, which pertains to the positive influence of MEF on BIM. The relevant explanations for these outcomes are further elaborated in the later discussion section.

The result in Table 5 and Figure 2 showed that all the paths of UTAUMT are confirmed. MPE ($t = 2.502$, $\beta = 0.124$, $p < 0.05$), MEE ($t = 3.027$, $\beta = 0.219$, $p < 0.05$), MFC ($t = 2.147$, $\beta = 0.119$, $p < 0.05$), and MSI ($t = 3.434$, $\beta = 0.275$, $p < 0.05$) can predict the behavioral intention, so hypothesis 4, hypothesis 5, hypothesis 6, and hypothesis 7 were supported. Furthermore, MET and BIM ($t = 5.269$, $\beta = 0.285$, $p < 0.05$), MET and MEA ($t = 6.152$, $\beta = 0.367$, $p < 0.05$), and BIM and MEA ($t = 7.972$, $\beta = 0.460$, $p < 0.05$) were statistically satisfied at 5% level of significance. Thus, hypothesis 2, hypothesis 3, and hypothesis 8 were supported. However, surprisingly, MEF and BIM ($t = 0.944$, $p > 0.05$) were not significant at a level of 0.05. Consequently, hypothesis 1 was not supported.

Table 6 shows that for BIM and MEA to metaverse banking service, all Q^2 values were more than 0, indicating the model was adequately predictive. The PLS-SEM model achieved high predictive performance since none of its root mean squared error (RMSE) indices was larger than the linear model benchmark in Table 7 [92].

Table 6: Predictive relevance (Q^2) and predictive accuracy (R^2).

	R square	Q^2 predict	RMSE	MAE
BIM	0.787	0.775	0.478	0.337
MEA	0.626	0.620	0.621	0.428

4.5. Importance-Performance Map Analysis (IPMA). Expanding on the PLS-SEM results (IMPA), this study looked at the importance-performance maps. Better strategic planning is made possible by IMPA because it identifies crucial target constructs that have a significant aggregate influence but poor performance. Table 8 and Figure 3 show what the IPMA found. All of the independent factors (MEE, MEF, MET, MFC, MPE, MSI, and BIM) were tested for how important they were and how well they worked. Concerning the importance measure, it is clear that MET

Table 7: PLS predict.

	Q^2 predict	PLS-SEM RMSE	PLS-SEM MAE	LM RMSE	LM MAE
BIM1	0.501	**0.806**	0.592	0.837	0.607
BIM2	0.489	**0.844**	0.609	0.858	0.618
BIM3	0.487	**0.895**	0.626	0.922	0.637
BIM4	0.502	**0.875**	0.623	0.885	0.638
BIM5	0.593	**0.721**	0.528	0.725	0.531
MEA1	0.409	**0.904**	0.670	0.913	0.672
MEA2	0.482	**0.753**	0.570	0.771	0.549
MEA3	0.461	**0.828**	0.608	0.859	0.611
MEA4	0.452	**0.848**	0.635	0.874	0.640

Note: figures in bold denote significance ($P < 0.05$).

Table 8: Importance-performance map analysis (IPMA).

	Importance (total effect)	Performance (index value)
BIM	0.460	80.173
MEE	0.101	81.397
MEF	-0.025	79.699
MET	0.498	80.022
MFC	0.055	79.309
MPE	0.057	81.619
MSI	0.127	80.591
Mean	0.182	80.401

is seen as the most important factor for predicting the adoption of metaverse banking services, followed by BIM, MSI, MEE, MPE, MFC, and MEF, in that order. In terms of the performance measure, it can be seen that MPE has the best value, followed by MEE, MSI, BIM, MET, MEF, and MFC, in that order. The emphasis should be on MET and BIM since the constructs have high importance (0.498; 0.460) but poor performance (80.022; 80.173).

4.6. Results of Artificial Neural Network Modelling (ANN). The widely used statistics software SPSS 25 was used to examine the neural network model. At this point, this model was fed the statistically significant factors from the SEM study. From the SEM study, six factors have been found to be important. So, six factors (06) were given as input variables in the input layers. These variables were shown as controls by the significant predictors MET, MPE, MEE, MFC, MSI, and BIM in Figures 4 and 5. The dependent variable in the output layer was found to be BIM in model A and MEA in model B for metaverse banking service adoption. Also, the overfitting neural network model problem was fixed using the cross-validation tool [93]. During the research phase, 10% of the data points were used for testing, and 90% were used for training [87]. Table 9 shows the RMSE values for both the training and testing data sets and the mean and standard deviation. The results show that model A has a mean RMSE value of 0.293 for training and 0.269 for testing. The training and testing numbers in model B are 0.318 and 0.324, respectively. These average RMSE values are pretty small, and the standard deviations are very low, which shows that the statistical results are more accurate [85].

The results also show that the extracted models are very good at capturing the links between the important factors and the output variables. All factors' average value was used to determine how important an outcome variable was in the sensitivity analysis. The standardized relative importance of each predictor in the model was found by dividing the relative importance of each predictor by the highest-value predictor. The average and normalized relative importance (%) of each indicator are shown in Table 10. However, the neural network model study results show that MSI is the most important indicator of BIM, followed by MET, MPE, MEE, and MFC. On the other hand, MET and BIM are as good at predicting MEA. In comparing the differences in ranking between PLS-SEM and ANN, the results in Table 11 showed that model A is consistent while model B is different.

4.7. Discussion. Fundamentally, this research has confirmed the objectives of proposing a new model UTAUMT to investigate the adoption of metaverse banking services, and the model explained 78.7% of the metaverse banking service intention to use along with 62.6% of the metaverse banking service adoption. Compared to the empirical results of the extended UTAUT models of Al-Saedi et al. [56], which explained 71.9% of intention, and the UTAUT2 models of Oliveira et al. [94], which explained 71.8% of intention, the new model in this study shows significant improvement in the explanatory and predictive power of the model. One of the reasons for this improvement is the rigorous instrument development and validation process by using face and content validity and a pilot test before using the instrument in fieldwork.

The findings of this study are somewhat consistent with the existing literature on applying UTAUT in other contexts. Four variables, MFC, MPE, MSI, and MEE, have a significant impact on behavioural intention to use metaverse banking services that is in line with previous studies in different contexts [63–65, 95]. Regarding MFC, the development and advancement of technology, particularly in virtual reality (VR), augmented reality (AR), and immersive experiences, can facilitate the adoption of metaverse banking. As technology becomes more accessible, affordable, and user-friendly, consumers are more likely to explore and engage with metaverse platforms and services. Moreover, intuitive and user-friendly interfaces make it easier for consumers to navigate and interact with metaverse banking platforms. When the user experience is streamlined and accessible, consumers are more likely to embrace the technology and feel comfortable conducting financial transactions within the metaverse, in the case of MEE. Along with that, in terms of MPE, when consumers are informed about the benefits, features, and potential use cases of metaverse banking, they are more likely to adopt and utilize these services. Interestingly, through the ANN analysis, MSI emerges as the most vital driver of behavioural intention to use metaverse banking services. This outcome differs from other previous research [56, 96], which does not exert that SI is not a key factor

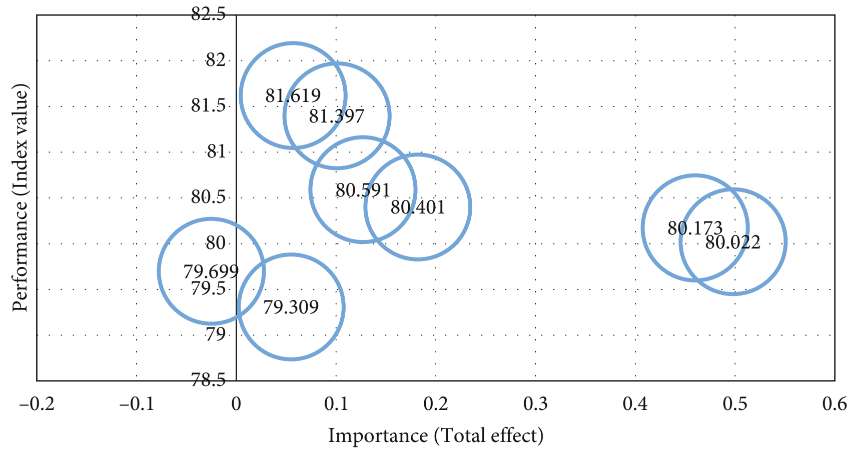

Figure 3: Importance-performance map analysis (IPMA).

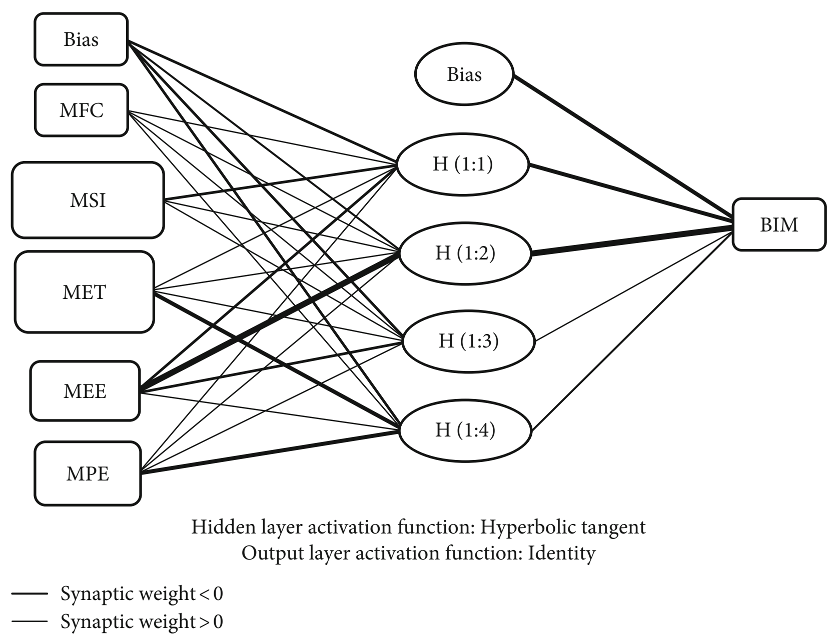

Figure 4: ANN model A.

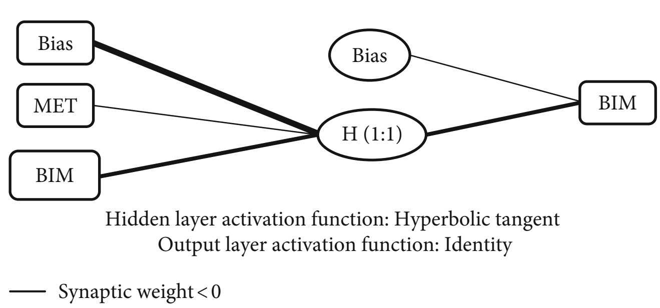

Figure 5: ANN model B.

driving intention to use technology. It is logical in the metaverse business banking because it is in the early stages of development and has yet to gain widespread popularity. However, the adoption of metaverse banking can be influenced by peer recommendations and influencer endorsements. For the former, positive experiences and recommendations from friends, family, or peers who have already adopted metaverse banking services can influence

Table 9: RMSE value for model A and model B.

Neural network	Model A: input MET, MPE, MEE, MFC, and MSI, and output is BIM						Model B: input MET and BIM, and output is MEA					
	Training			Testing			Training			Testing		
	N	SSE	RMSE	*N*	SSE	RMSE	*N*	SSE	RMSE	*N*	SSE	RMSE
ANN1	439	314.934	0.305	52	45.921	0.327	432	385.171	0.345	59	52.556	0.322
ANN2	440	304.942	0.289	51	26.225	0.216	440	384.243	0.320	51	49.439	0.431
ANN3	438	298.278	0.274	53	40.024	0.302	435	374.058	0.317	56	52.994	0.357
ANN4	429	295.493	0.284	62	43.973	0.355	449	366.832	0.303	42	40.475	0.333
ANN5	435	322.144	0.294	56	31.502	0.179	442	370.680	0.317	49	47.400	0.388
ANN6	445	330.256	0.317	46	27.440	0.174	433	373.155	0.312	58	42.054	0.224
ANN7	437	308.183	0.286	54	30.590	0.259	448	371.687	0.304	43	34.140	0.279
ANN8	443	320.463	0.284	48	35.907	0.375	433	388.042	0.333	58	57.224	0.328
ANN9	434	311.626	0.302	57	35.375	0.263	442	372.640	0.310	49	44.418	0.306
ANN10	440	324.622	0.296	51	26.346	0.235	439	371.960	0.317	52	34.440	0.269
Means		313.094	0.293		34.330	0.269		375.847	0.318		45.514	0.324
SD		10.904	0.012		6.799	0.067		6.836	0.012		7.431	0.057

Table 10: Sensitivity analysis.

Neural network	Model A: input MET, MPE, MEE, MFC, and MSI, and output is BIM					Model B: input MET and BIM, and output is MEA	
	MET	MPE	MEE	MFC	MSI	MET	BIM
1	0.144	0.242	0.203	0.159	0.252	0.198	0.802
2	0.227	0.191	0.138	0.149	0.295	0.483	0.517
3	0.258	0.188	0.160	0.163	0.231	0.444	0.556
4	0.185	0.19	0.185	0.197	0.243	0.448	0.552
5	0.255	0.203	0.130	0.135	0.277	0.421	0.579
6	0.238	0.232	0.128	0.141	0.261	0.432	0.568
7	0.227	0.212	0.213	0.075	0.273	0.416	0.584
8	0.223	0.264	0.190	0.132	0.191	0.493	0.507
9	0.203	0.222	0.113	0.136	0.326	0.425	0.575
10	0.172	0.19	0.234	0.162	0.242	0.385	0.615
Average relative importance	0.213	0.213	0.169	0.145	0.259	0.415	0.586
Normalized relative importance (%)	92.10%	68.20%	65.60%	53.80%	100.00%	91.40%	100.00%

others to follow suit. When people see others in their social circles benefiting from and enjoying metaverse banking, they may be more inclined to try it themselves. Influencers and thought leaders with a strong following and influence in the virtual world or financial sector can promote metaverse banking services to their audience. Their endorsement and positive reviews can sway the opinions and decisions of their followers, leading to increased adoption of these services.

Another notable finding is that MET has a direct positive impact on behavioural intention and adoption of metaverse banking services which implies that when consumers trust the metaverse banking service, they are more likely to use it. Trust is a critical factor in adopting and using any financial service [97], including metaverse banking. Security measures, reputation, openness, regulatory compliance, user education, and proven dependability are important in trust-building. Metaverse banking service providers may increase confidence and boost demand for metaverse financial services by addressing these concerns.

Finally, MEF was found to have no direct influence on BIM, which implies that the financial resources do not drive customers to use metaverse banking services because metaverse banking focuses on the virtual realm rather than traditional financial transactions. Metaverse banking often involves virtual currencies that exist solely within the virtual environment. These currencies are typically separate from traditional currencies and may have their mechanisms for acquisition and use. As a result, the availability of financial resources in the traditional sense may be a minor factor in adopting metaverse banking services.

Table 11: Comparison between PLS-SEM and ANN results.

PLS path	Path coefficient	ANN results (normalized relative importance (%))	Ranking (PLS-SEM) (path coefficient)	Ranking (ANN) (normalized relative importance (%))	Remark
Model A					
MFC ⟶ BIM	0.119	53.80%	5	5	Match
MPE ⟶ BIM	0.124	68.20%	4	3	Not match
MSI ⟶ BIM	0.275	100.00%	2	1	Not match
MEE ⟶ BIM	0.219	65.60%	3	4	Not match
MET ⟶ BIM	0.285	92.10%	1	2	Not match
Model B					
MET → MEA	0.367	91.40%	2	2	Match
BIM → MEA	0.460	100.00%	1	1	Match

5. Implications, Conclusions, and Limitations

5.1. Theoretical Implications. The main contribution of the research study is the introduction and development of UTAUMT, which includes MEE, MPE, MFC, and MSI. UTAUMT investigates metaverse banking adoption based on metaverse-experienced users in nonorganizational situations, making it more thorough than typical IT/IS models. Traditional IT/IS models are centred on organizational settings and are generally required for work. Researchers can use this paradigm with other constructs to further analyze the metaverse's environment. To the authors' knowledge, research has yet to introduce the new framework through the rigorous instrument development and validation process. Second, most earlier constructs to examine the adoption were adapted from IT/IS theories and used in metaverse studies, which may not represent the real metaverse environment. Metaverse's unique features distinguish it from other environments. Given the variations in views, customers would act differently. The research also introduces MET and MEF structures. The integrated constructs are taken as antecedents of intention and adoption of metaverse banking services since customers' metaverse preferences rely on trust and finances. These new constructs increase the explanation of the adoption investigated in metaverse banking service. This is of great significance for exploring the impact of trust and financial resources on intention and adoption. Future researchers should connect the new components to additional metaverse technology investigations. Finally, this study enriches the literature on metaverse adoption in the banking service context. Existing literature mainly focuses on the metaverse adoption in education [14], retailing [16], tourism [15], and healthcare [17], while paying less attention to banking services. Our research reveals the impact of MET on the intention and adoption of metaverse banking services, thus expanding the theoretical basis for studying metaverse banking service adoption.

5.2. Managerial Implications. There are four major managerial implications of this study. Firstly, metaverse banking service is new, and banking managers should develop comprehensive marketing and educational campaigns to raise awareness about metaverse banking services. Moreover, managers should highlight the benefits, unique features, and potential opportunities that metaverse banking can offer customers by using various channels, including social media, targeted advertising, and partnerships with influencers or virtual world platforms, to reach the target audience. Secondly, metaverse effort expectancy is one factor driving the adoption. Managers should focus on providing a seamless and user-friendly experience within the metaverse banking platform. Along with that, bank managers should invest in intuitive interfaces, responsive design, and personalized features that cater to customers' specific needs and preferences in the virtual environment. A smooth and engaging user experience can attract more customers and encourage adoption. Thirdly, trust in metaverse banking services is proved as an important factor. As a result, bank managers should establish robust security measures and emphasize the trustworthiness of the metaverse banking services by either implementing industry-leading security protocols, data privacy measures, and encryption technologies to protect customer data and virtual assets or communicating the importance of security and privacy to customers and providing clear information about the steps taken to ensure their safety within the metaverse banking platform. Lastly, building a strong community around metaverse banking by facilitating user interactions is the best strategy to attract more customers. The bank manager should also consider organizing virtual events, webinars, or meetups to connect users and provide educational opportunities. A vibrant and engaged community can attract more customers and foster loyalty.

5.3. Conclusions. Overall, this study proposed the new model UTAUMT and two new constructs to investigate the adoption of metaverse banking services. The research indicates that four key variables—metaverse facilitating conditions (MFC), metaverse performance expectancy (MPE), metaverse social influence (MSI), and metaverse effort expectancy (MEE)—affect consumers' intentions to use metaverse banking services. Virtual reality (VR), augmented reality (AR), and immersive experiences are all getting better, which helps create metaverse facilitating conditions that make metaverse banking more accessible, affordable, and easy to use. A seamless user experience, with easy-to-use interfaces and navigation, makes consumers feel at ease and makes it easier for them to do financial transactions in the metaverse. This makes them more likely to use metaverse banking services. The consumers' cognitive perceptions of metaverse performance expectancy, which include their beliefs and expectations about how well metaverse banking services will work and what benefits they will bring, play a key role in getting people to adopt them. metaverse social influence is also important because it shows how peer recommendations and endorsements from influential people can have a big effect on what people decide to do. Metaverse banking is still in its early stages, so recommendations from social circles and thought leaders can have a big impact on how decisions are made and lead to more people using it. The study also shows that consumers' trust in metaverse banking services (metaverse trust (MET)) has a direct, positive effect on their intentions to change their behavior. This shows that trust in the security, privacy, and dependability of these services is a key factor in getting people to use them. Trust is built through things like strong security measures, a good reputation, following the rules, educating users, and being reliable. This makes more people want to use metaverse financial services. Surprisingly, the presence of traditional financial resources (metaverse financial resources (MEF)) does not directly drive consumers to use metaverse banking services. This is because the virtual realm often uses its own currencies and systems that are different from traditional financial transactions. This suggests that the availability of traditional financial resources may not have much of an effect on how many people use metaverse banking. In essence, the study gives a full picture of how the complex interaction of many different factors drives people to use metaverse banking services. It also shows how important it is to address technological, social, and trust-related issues to encourage widespread use in this new field.

5.4. Limitations. Caution should be used in generalizing the findings of this research since the sample may not be representative of the community due to the sampling technique and size used. Quota sampling is an option for higher sample sizes in future investigations. Not only was MET effectively included in the UTAUMT framework, but its variation also explained behavioural intention and adoption of metaverse banking services. This suggests that factors outside the UTAUMT most likely explain metaverse adoption. As a result, other variables that could potentially explain adoption should be included in future research. Furthermore, no mediator was included in the research model of this study. Therefore, it is suggested that, to provide companies with more nuanced knowledge, future studies investigate the moderating impacts of human factors, including age, gender, and level of education. Due to the study's narrow emphasis on Vietnam, further research on the cultural differences of mobile social commerce users may benefit from a cross-country comparison, particularly within Asia countries.

Appendix

A. List of Items Used after Developing the Measurement Instrument

A.1. Metaverse Effort Expectancy (MEE) Adapted from Venkatesh et al. [20]. MEE1. Metaverse banking service is easy to use.

MEE2. My interaction with the metaverse banking service is clear and understandable.

MEE3. It is easy for me to become skillful at using metaverse banking service.

MEE4. I think that learning to operate the metaverse banking service would be easy for me.

A.2. Metaverse Performance Expectancy (MPE) Adapted from Venkatesh et al. [20]. MPE1. Metaverse banking service system is useful in my daily life.

MPE2. Metaverse banking service system helps me to accomplish tasks more quickly.

MPE3. Metaverse banking service system increases my productivity.

MPE4. Metaverse banking service is useful to carry out my tasks.

A.3. Metaverse Social Influence (MSI) Adapted from Venkatesh et al. [20]. MSI1. People who are close to me think that I should use the metaverse banking service system.

MSI2. People who influence my behaviour think that I should use the metaverse banking service.

MSI3. People whose opinions that I value prefer that I use the metaverse banking service system.

MSI4. Friend's suggestion and recommendation will affect my decision to use the metaverse banking service.

MSI5. Family/relatives have influenced on my decision to use metaverse banking service.

A.4. Metaverse Facilitating Condition (MFC) Adapted from Venkatesh et al. [20]. MFC1. I have the resources necessary to use the metaverse banking service.

MFC2. I have the knowledge necessary to use the metaverse banking service.

MFC3. Metaverse banking service is compatible with other systems I use.

A.5. Metaverse Trust (MET) Adapted from Baptista and Oliveira [88]. MET1. Metaverse banking service system is trustworthy.

MET2. I believe that all the transaction data are confidential.

MET3. I believe that I would get an immediate confirmation message when the transaction is completed.

MET4. I would expect that the metaverse banking service system to be reliable.

A.6. Metaverse Financial Resources (MEF) Adapted from Ooi and Tan [48]. MEF1. The annual fees of metaverse banking service are expensive for me.

MEF2. The transaction fees are expensive.

MEF3. The cost of metaverse banking service is high for me.

A.7. Behavioural Intention to Use Metaverse Banking Service (BIM) Adapted from Venkatesh et al. [20]. BIM1. I intend to use the metaverse banking service system in the future.

BIM2. I expect that I will use the metaverse banking service system in my daily life.

BIM3. I expect to use the metaverse banking service system frequently.

BIM4. Given the opportunity, I will use the metaverse banking service.

BIM5. I will think about using a metaverse banking service.

A.8. Metaverse Banking Services Adoption (MEA) Adapted from Ajzen [63]. MEA1. I consider myself an intensive user of the metaverse banking service.

MEA2. As soon as possible, I want to use the metaverse banking service more intensively.

MEA3. In general, I believe that I use the metaverse banking service satisfactorily.

MEA4. The use of the metaverse banking service allows the creation of differentiated services or processes.

Data Availability

Data is available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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