Investigating the Impact of Metaverse Characteristics on User Behavior through the Combination of PLS-SEM and NCA within the Extended Value-Based Adoption Model*

확장된 가치기반 수용 모델 내에서 PLS-SEM과 NCA의 결합을 통한 메타버스 특성이 사용자 행동에 미치는 영향에 관한 연구

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The present study employed the extended value-based adoption model to examine the determinants that influence users' intention to utilize the Metaverse. The determinants impacting users' intention to adopt the Metaverse were identified as technical attributes (seamlessness, concurrence, telepresence, interoperability and economy flow) and personal characteristics (self-efficacy and social influence). For this purpose, the data obtained from 327 people was analyzed using SPSS 22 and Smart PLS 4. The results showed that perceived usefulness and perceived enjoyment were found to have a positive influence on perceived value. Meanwhile, technicality and perceived fee did not have a statistically significant negative effect on perceived value. Among the Metaverse characteristics, telepresence, interoperability, concurrence and economy flow were found to have a positive influence on perceived usefulness, and telepresence, interoperability and concurrence were found to have a positive influence on perceived enjoyment. Meanwhile, the NCA results indicate that telepresence, interoperability, and concurrence are necessary conditions for perceived usefulness, while concurrence is the only necessary condition for perceived enjoyment. In addition, we found that social influence and self-efficacy had a positive influence on intention to use the Metaverse. This study is significant in that it empirically analyzes the drivers of user acceptance of the Metaverse.

Key Words: Metaverse, the extended value-based adoption model, NCA(Necessary Condition Analysis)

Submission Date: 06. 05. 2023 Revised Date: (1st: 08. 21. 2023) Accepted Date: 08. 25. 2023

* This research is supported by Hansung university research fund.

Ⅰ. Introduction

As the coronavirus pandemic hits the world and physical interaction becomes difficult, people are looking for services that allow them to have a reality-like experience online, and for this reason, the metaverse is attracting attention as a next-generation platform that connects SNS in the post-coronavirus era. The term "Metaverse" refers to a digitally constructed environment that combines elements of virtual reality and transcendence, denoted by the prefix "Meta," with the concepts of a world and universe, represented by the term "Universe." This amalgamation results in a hyper-connected and hyper-realistic digital world. In essence, the concept refers to a virtual setting that transcends the limitations imposed by the physical and functional aspects of our tangible surroundings (Kim, 2020; Kim & Lee, 2023). In the future, users are expected to spend more time in the Metaverse ecosystem, and the transition to a Metaverse ecosystem where various social, economic, and cultural activities are connected or converged with the virtual world is expected to accelerate. With the prospect of the Metaverse, a virtual digital ecosystem beyond the real world, becoming a future engine of growth, various industries are predicting the possibility of innovative change through the Metaverse and exploring various ways of using it.

Despite this surge of interest in the Metaverse around the world, there is no guarantee that the Metaverse will lead to mass adoption through active consumer acceptance. As evidenced by the examples of 3D TV, smart TV, and video phone, it is apparent that new media technologies might encounter consumer resistance and experience a delay in achieving widespread adoption, contrary to earlier projections. Hence, in order to facilitate the widespread acceptance and adoption of the Metaverse while mitigating potential consumer resistance, it is imperative to conduct research aimed at forecasting and analyzing the determinants that impact consumer acceptability.

On the other hand, the results of the literature analysis on Metaverse research achievements show that there are not many Metaverse-related studies in general, and studies from the user perspective are very scarce. The trends of Metaverse-related research, including related technologies and services, can be summarized as follows.

First, research on the concept, status, and direction of development. As Metaverse research is currently in its infancy, most of the studies conducted so far have discussed the concept of Metaverse, definitions of types, technology and policy trends, future development prospects, and activation measures(Lee et al., 2021; Go et al., 2021; Lee, 2021). Second, research on the technical dimension. In Korea, there have been many studies on

the technical implementation and development of Metaverses, focusing on engineering (Duan et al., 2021; Park & Kim, 2022). Third, research on Metaverses from the user's perspective. To date, studies on the user side of the Metaverse have mostly focused on services using augmented reality and virtual reality technologies, which are sub-constructs of the Metaverse, and their acceptance intentions (Badamasi et al., 2021; Xi & Hamari, 2021; Zhang et al., 2020; Lee et al., 2021; Jeon & Nam, 2020; Hong & Han, 2020).

Despite the industry and user interest and expectations for the Metaverse, there are relatively few studies on Metaverse acceptance and usage intentions that have conducted value assessment and understanding from the user's perspective, taking into account the characteristics of the Metaverse. In addition, for Metaverse services and content to be widely accepted and disseminated, it is necessary to evaluate, understand, and explore their value by considering various factors that affect users' intention to use them in the early stages of development. Therefore, it is necessary to conduct more research in this area in the future.

There are many factors that influence the intention to use Metaverse services and contents in the early stages of development. The Technology Acceptance Model (TAM), which has been the basis of most studies so far, is a model that focuses on technical characteristics. Therefore, the first objective of this study is to investigate how the characteristics of the metaverse influence the acceptance of the metaverse using VAM(Value-based Adoption Model) rather than TAM. Second, instead of the existing piecemeal approach to technology acceptance, we tried to consider the technical aspects of Metaverse (telepresence, interoperability, seamlessness, concurrence, economy flow) and personal aspects (social influence and self-efficacy) along with the economic aspects (benefits and sacrifices) of accepting new technologies. Third, we also conducted a necessary condition analysis to determine whether Metaverse characteristics were necessary for perceived usefulness and perceived enjoyment.

Ⅱ. Conceptual framework and Hypothesis

2.1 VAM(Value-based Adoption Model)

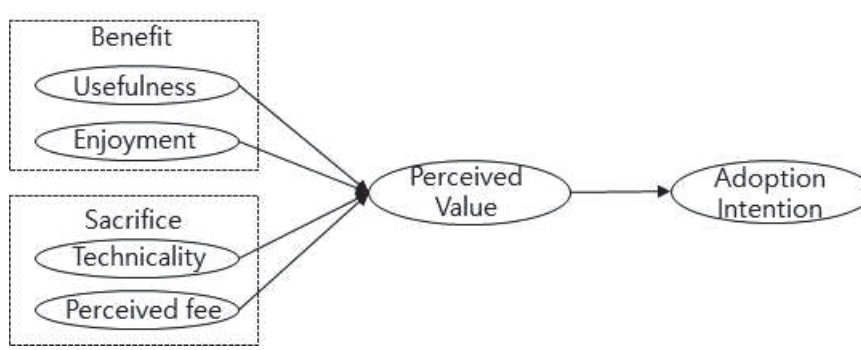
The Value-based Adoption Model (VAM) is a theory first proposed by Kim et al. (2007), and is an acceptance model that focuses on the value maximization of individual consumers in that the Technology Acceptance Model (TAM), a representative acceptance model proposed by Davis (1989), has limitations in explaining the acceptance factors of new ICT technologies, and ICT users should be

perceived as 'consumers' rather than technology users (Kim et al., 2007).

The value-based adoption model recognizes individuals as technology users and focuses on maximizing consumer value. It classifies benefits (usefulness, enjoyment) and sacrifices (technicality, perceived fee) as the main variables of perceived value and analyses the intention to use. Perceived value is an exchange transaction of benefits and sacrifices arising from the choice of new products and services, and analyses the perceptual factors that are reflected in users' decisions. In other words, the value-based adoption model is a model that analyses consumers' intention to adopt technology based on perceived value to overcome the limitations of the technology acceptance model in the new technology environment. Figure1 shows the value-based adoption model (Kim et al., 2007), and consumers' perception of value is a determinant of adoption intention, and each of the beliefs of benefit, which consists of usefulness and enjoyment, and sacrifice, which consists of technicality and perceived fee, are mediated through perceived value (Kim et al., 2007).

The value-based adoption model, which recognizes technology users as consumers and tests their acceptance intention based on their perceived value, is a useful model for studying consumer acceptance of emerging ICT-related products and services.

Perceived benefits consist of extrinsic, cognitive usefulness and intrinsic, emotional enjoyment (Kim et al., 2007). Perceived usefulness is defined as the total value of a user's perceived performance when using a new technology, and is similar to product quality in marketing, which is defined as a customer's cognitive assessment of a product's excellence /superiority. Perceived enjoyment is the degree to which the usage behavior itself is perceived as enjoyable, excluding the expected performance outcome of the product usage behavior. Individuals who experience immediate pleasure and enjoyment from a product



〈Figure 1〉 Value-Based Adoption Model(VAM)

use behavior, and who perceive it as having enjoyment value beyond its instrumental value, are more likely to use the product. This concept is consistent with emotional value, which Sweeney & Soutar (2001) define as the utility derived from the feeling or affective state produced by a product.

Perceived sacrifice includes both monetary sacrifice, which is usually measured based on the customer's perception of the actual price paid, including the actual price of the product, and non-monetary sacrifice, which is the unsatisfactory expenditure of time, effort, and money in purchasing and consuming the product; the monetary sacrifice component consists of the perceived fee and the non-monetary sacrifice component consists of technicalities (Kim et al., 2007).

Kim et al. (2007) proposed the VAM and applied it to a study of the intention to use mobile Internet and found that the intention to use mobile Internet is determined by the perceived value of mobile internet and that all five hypotheses were supported, namely that the perceived usefulness, enjoyment, fee, and technicality of mobile Internet have a significant effect on the perceived value. In addition, perceived sacrifices were found to have a greater impact on perceived value than perceived benefits, which is explained by the fact that even if customers perceive the benefits of mobile internet, they will not consider it worth using unless they perceive that the benefits outweigh the sacrifices (Kim et al., 2007).

H1: Perceived usefulness will positively influence perceived value.
H2: Perceived enjoyment will positively influence perceived value.
H3: Technicality will negatively influence perceived value.
H4: Perceived fee will negatively influence perceived value.
H5: Perceived value will positively influence intention to use.

2.2 Metaverse Attributes

In order to derive the characteristics of a Metaverse, it is first necessary to review the existing research on the factors that facilitate customer experience in a Metaverse. Prominent figures and researchers who have recently discussed Metaverse characteristics include Clink CEO Chad Richman (2020), Cuofano (2022), and Roblox CEO Baszucki (2020), and researchers who have recently discussed Metaverse characteristics include Go et.al. (2021) and Kim and Shin (2021).

CEO Chad Richman described the common characteristics of the metaverse as "collective virtual shared space," meaning an open virtual space shared by all; "convergence with physical reality," meaning the connection between the digital and virtual worlds; and "persistence,"

meaning that the metaverse itself exists forever, regardless of whether an individual user accesses it or not. Cuofano(2022) outlined the key characteristics of a technologically evolving metaverse as Persistence, Synchronicity, Accessibility, Economic function, Scope, Interoperability, and Contribution. Baszucky(2020) proposed eight elements : Identity, Friends, Immersive, Anywhere, Low Friction, Variety of Content, Economy, Civility. Go et al. (2021) proposed five elements: canon, creator, currency, continuity and connectivity.

While many scholars may use different terminology, the fundamental attributes of a Metaverse exhibit minimal divergence across their perspectives. In their recent publication, Kim and Shin (2021) introduced a comprehensive description of the key attributes of a Metaverse, drawing upon the concept of the ASF framework. These attributes include Seamlessness, Presence (Telepresence), Interoperability, Concurrence, and Economy Flow. According to the synopsis provided by Kim and Shin (2021), the attributes of the Metaverse can be delineated as follows.

Telepresence is a situation where there is no physical contact, but the user has a sense of spatial reality. Virtual reality is a representative channel for enhancing the sense of telepresence (Kim & Shin, 2021). The term "Telepresence" can be described as the individual's subjective perception of being physically present in a particular environment (Davis et al., 2009). It also encompasses the idea of being connected not just to a digital representation of oneself but also to other digital spaces and elements inside the actual world (Tasa & Görgülü, 2010). This phenomenon arises due to the significance of platforms in establishing a comparable encounter, hence augmenting the feeling of being fully engaged in an environment that lacks physical interaction for the user (Kim et al., 2022). Immersion in virtual worlds is crucial to enhance the sense of telepresence, and devices such as VR/AR devices can help. In addition, it is not only the technical aspects of VR and AR that create a sense of telepresence, but also a well-crafted story, or narrative, that creates a sense of reality (Koo et al., 2022).

The study conducted by Lee et al. (2021) examined the various aspects that influence individuals' desire to utilize virtual reality (VR)-based digital content subscription services. The researchers discovered that telepresence, as one of the key attributes of VR content, positively influenced individuals' perceptions of both usefulness and enjoyment. Furthermore, Shin (2021) found that the higher the telepresence of social VR content, the higher the perceived usefulness and perceived enjoyment. Han & Ahn (2019) verified that telepresence influenced enjoyment and usefulness in a distribution environment using VR technology, which in turn influenced future intentions to use VR.

H6: Telepresence will have a positive influence on perceived usefulness.

H7: Telepresence will have a positive influence on perceived enjoyment.

Interoperability means that the real world and the data in the Metaverse are connected so that the results of the user's experiences and actions in the Metaverse are connected to the real world, and the experience in the Metaverse ecosystem is made more convenient by using information from the real world (Kim & Shin, 2021). Furthermore, the concept of interoperability pertains to the integration of data and information between the real world and the Metaverse. This integration enables the linkage of user experiences and actions in the Metaverse to real-world outcomes, thereby enhancing the richness and convenience of the Metaverse experience through the utilization of real-world information (Kim & Lee, 2023). The loss in immersion of an online platform is likely to occur when the information provided is disconnected from real-world experiences or when it is not effectively shared among users (Koo et al., 2022). An example is the smart lens that exists in search engines such as Google and Naver. They allow us to see information about a product, its rating, and even where it's sold, by simply pointing the camera at it. Another example is when you use social media, such as Facebook, you may have seen personalized ads based on the information you have viewed (Kim & Shin, 2021).

According to McMillan and Hwang (2002), there exists a positive correlation between the perceived level of interoperability inside a specific system and the extent to which it influences favorable sentiments towards the technology. In a study conducted by Park and Nam (2017), the researchers examined the impact of perceived interoperability on information acceptance within the context of a mobile health information service. The findings of the study indicated that a greater perception of interoperability had a positive influence on both perceived usefulness and perceived ease of use. Consequently, this positive influence resulted in an increased intention to use the mobile health information service. According to Cha (2019), enhancing interoperability is crucial in the context of interactive content as it serves as a strategic tool that fosters more user engagement and immersion in the content, and applied the technology acceptance model to examine the acceptance of theatre advertisements using NFC technology, and found that interoperability positively increased perceived usefulness and perceived ease of use. In addition, Shin (2021) found that the higher the interoperability of social VR content, the higher the perceived usefulness and perceived enjoyment.

H8: Interoperability will have a positive

influence on perceived usefulness.

H9: Interoperability will have a positive influence on perceived enjoyment.

Seamlessness is the uninterrupted connection of experiences created in the metaverse: you can play a game with your own avatar, go shopping and interact with your friends without logging back in (Kim & Shin, 2021). Additionally, the concept of seamlessness pertains to the continuity of functionality inside a digital environment, even in instances where the user is away from it (Gilbert, 2011). As an illustration, within the context of Fortnite, individuals have the ability to engage in a battle royale-style gaming experience on a singular platform, thereafter transitioning seamlessly to a party royale area to spectate a live performance, or alternatively, to a communal space for the purpose of engaging in social interactions (Kim & Lee, 2023). The significance is in the ability to perform many tasks on a single platform, while also establishing a connection between one's activities and their historical record. The linkage between memories and information is established through continuity, rather than the introduction of novel connections and diverse characters across many locations, mirroring the manner in which individuals navigate their real-life experiences (Koo et al., 2022).

H10: Seamlessness will have a positive influence on perceived usefulness.

H11: Seamlessness will have a positive influence on perceived enjoyment.

Concurrence is an environment in which multiple users can operate together in the same metaverse and have a variety of different experiences at the same time. A virtual reality game, which is accessed by an individual and played according to a pre-created scenario, differs from this feature of the metaverse (Kim & Shin, 2021). Furthermore, the concept of concurrence posits that a platform should possess the capability to accommodate several users simultaneously (Kim & Lee, 2023). It refers not only to the connection of avatars in virtual reality, but also to another level, from physical reality to various digital spaces and surroundings (Tasa & Görgülü, 2010), meaning that a large number of users in remote physical locations can interact simultaneously (Gilbert, 2011). In the context of the real world, individuals do not independently generate and augment knowledge, but rather engage in collective endeavors to disseminate a diverse range of information (Kim & Lee, 2023). According to Kim et al. (2022), in order for a platform to possess value, it is imperative that it initially acquires a substantial user base.

H12: Concurrence will have a positive influence on perceived usefulness.

H13: Concurrence will have a positive influence on perceived enjoyment.

Economy flow refers to economic activities that allow users to trade goods and services based on the monetary instruments and transaction methods provided within the platform (Kim & Shin, 2021). Additionally, economy flow is the concept of whether the products or services available on the platform can be traded. The categorization of items can be based on their consumption patterns, irrespective of their production locations. These patterns include the consumption of offline products through online channels, the consumption of online products through online channels, and the consumption of online products through offline channels (Guo & Chow, 2008). This particular range of transactions has the potential to extend the duration of user engagement with the platform. In the context of gaming, users often want various products to personalize their character or enhance their character's progression. However, relying solely on in-platform activities may not suffice to accomplish their objectives. Consequently, users may resort to utilizing actual currency as a means to facilitate their progress (Kim & Lee, 2023). It is crucial to possess the capability to engage in trading activities within the platform, as it enables users to acquire distinctive assets within the Metaverse or access convenient features. This, in turn, promotes the long-term utilization of the platform (Kim et al., 2022).

H14: Economy Flow will have a positive influence on perceived usefulness.

H15: Economy Flow will have a positive influence on perceived enjoyment.

2.3 Individual Attributes

Social influence is defined as the extent to which important people in the user's life feel that the user should use a new information technology (Venkatesh et al. 2003). According to the theory of influence, individuals are inclined to adopt the viewpoints of those they consider significant within their social circles (Kim & Lee, 2023). When individuals are faced with little information or uncertainty, they tend to engage in internalization, a cognitive process whereby they construct their own opinions with the assistance of others (Deutsch & Gerard, 1955).

A study by Lee (2005) found that social influence through this internalization process indirectly affects the intention to use through perceived usefulness. In addition, social influence was found to have a static impact on perceived usefulness and intention to utilize the Metaverse (Oh, 2021). However, most of the existing studies have investigated whether social influence affects usage intention (Venkatesh et. al, 2003; Choi et. al,

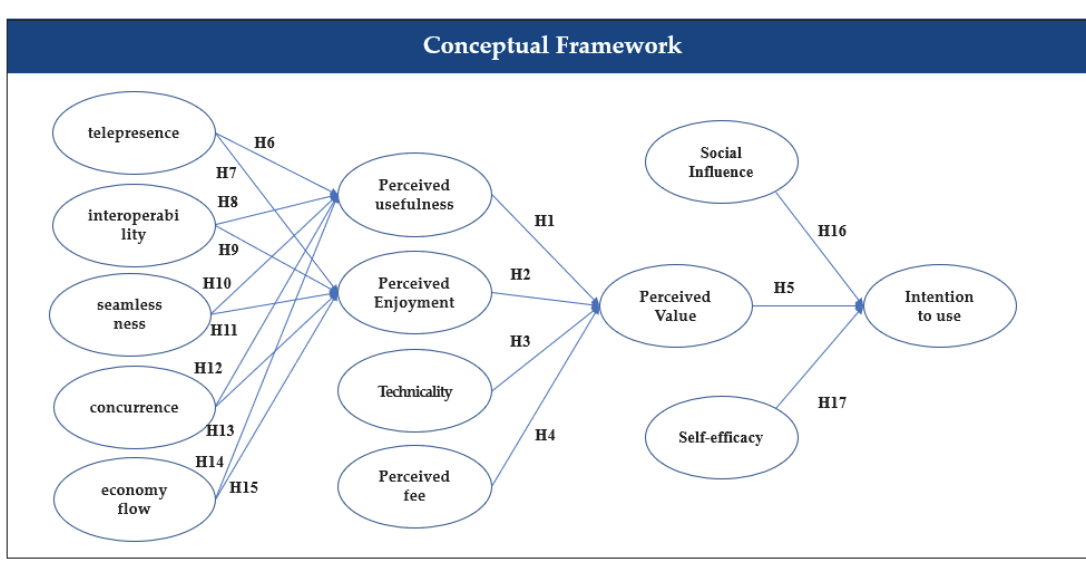
2017; Oh, 2021). Therefore, in this study, we hypothesized that social influence only affects intention to use.

H16: Social influence will have a positive influence on intention to use the Metaverse.

Self-efficacy refers to the degree to which a person believes he or she has the ability or skills to use a new innovative technology or product effectively (Ellen et al., 1991). Self-efficacy has been shown to influence an individual's decisions, efforts, and continuation of behavior (Compeau & Higgins, 1995). Previous studies have shown that higher self-efficacy has a positive effect on innovation acceptance (Ellen et al., 1991; Chen et al., 2009; Dabholkar & Bagozzi, 2002; Hirschman, 1980). Previous studies have tested the hypothesis of the effect of self-efficacy on intention to use and found it to be statistically significant (Choi et. al, 2017; Oh, 2021). Therefore, in this study, self-efficacy, which is influential in the early stages of consumer acceptance and diffusion, is an important variable influencing intention to use Metaverse, and the following hypotheses are formulated.

H17: Self-efficacy will have a positive influence on intention to use the Metaverse.

The following conceptual framework is formed 〈Figure 2〉.



〈Figure 2〉 Conceptual Framework

Ⅲ. Methods

3.1 Sample

Since the technical and personal characteristics of the metaverse platform are related to the adoption of the metaverse, the survey conducted for this study specifically focuses on individuals who possess prior experience with the metaverse platform. To achieve this, the researchers employed a quota sampling technique based on gender and age, as suggested by Kim and Lee (2023). The survey for the study was conducted with the assistance of an online research agency over a duration of two days in February 2023. The research agency's online panel was utilized to collect a total of 327 replies by quota sampling based on gender and age. The respondents were individuals who have utilized the Metaverse platform at least once, encompassing both males and females ranging from teenagers to individuals in their sixties residing in Korea. The demographic profile of the participants is presented in 〈Table 1〉. The sample's mean age was 31, with 76 individuals (23.2%) falling within the teenage and younger age group, 83 individuals (25.4%) falling within their 20s, 82 individuals (25.1%) falling within their 30s, and 86 individuals (26.3%) falling within their 40s and older. Additionally, there were 159 males (48.6%) and 168 females (51.4%) in the sample.

The purpose of using the Metaverse was more likely to be for enjoyment and fun (271, 82.9%) than for exploring and learning new information (56, 17.1%).

Among the participants, it was found that 115 individuals (equivalent to 35.2% of the total sample) utilize Minecraft as their primary Metaverse platform. This was followed by 75 respondents (22.9%) who reported using ZEPETO as their primary platform, 61 individuals (18.7%) who indicated Animal Crossing as their primary platform, 51 participants (15.6%) who reported Roblox as their primary platform, 12 individuals (3.7%) who stated using Gather Town as their primary platform, another 12 respondents (3.7%) who reported Ifland as their primary platform, and finally, only one participant (0.3%) who mentioned Fortnite as their primary platform.

Furthermore, it is worth noting that 37 individuals, accounting for 11.3% of the total respondents, utilize the Metaverse platform on a near-daily basis. Additionally, 71 respondents (21.7%) reported using the platform every 2-3 days, while 69 respondents (21.1%) engage with it once a week. Moreover, 45 individuals (13.8%) utilize the platform every 2-3 weeks, and a majority of 105 respondents (32.1%) reported using it once a month or less frequently.

〈Table 1〉 Sample description (N = 327)

Construct		Frequency (N)	Percent (%)
Gender	Female	168	51.4
	Male	159	48.6
Age	~19	76	23.2
	20~29	83	25.4
	30~39	82	25.1
	40~	86	26.3
Purpose of using Metaverse	Utilitarian	56	17.1
	hedonic	271	82.9
Preferred Metaverse Platforms	Minecraft	115	35.2
	ZEPETO	75	22.9
	Animal Crossing	61	18.7
	Roblox	51	15.6
	Gather Town	12	3.7
	Ifland	12	3.7
	Fortnite	1	0.3
Frequency of using Metaverse	Almost every day	37	11.3
	Once every 2-3 days	71	21.7
	Once a week	69	21.1
	Once every 2-3 weeks	45	13.8
	Once a month or less	105	32.1

3.2 Measurement

The study incorporates a set of variables, consisting of five independent variables that represent various features of the Metaverse (telepresence, interoperability, seamlessness, concurrence, and economy flow), as well as two independent factors that capture individual traits (Social Influence and Self-efficacy), five parameters (Perceived Usefulness, Perceived Enjoyment, Technicality, Perceived Fee, Perceived Value), and the dependent variable (Intention to use) are 13 in total, and are operationally defined as shown in 〈Table 2〉 based on past studies.

3.3 Data Analysis

3.3.1 PLS Path Modeling

This study employed partial least squares (PLS) path modelling to estimate the relationships hypothesized in this model. There are two approaches for specifying and testing hypothesized relationships in path analysis (Hair et al., 2010): covariance-based structural equation modeling (CB-SEM) and PLS-SEM).

〈Table 2〉 Operational definition of variables

Construct	Operational Definition	Related studies
Telepresence	Perceived psychological identification in the context of using metaverse services	Kim et. al.(2022), Davis et al.(2009), Dionisio et al.(2013), Gilbert(2011), Guthrie et. al.(2011), Noor(2010), Tasa and Görgülü(2010)
Interoperability	The extent to which data and information on the Metaverse platform interoperates with the real world when accessed by users	Kim et. al.(2022), Cammack(2010), Davis et al.(2009), Dionisio et al.(2013), Noor(2010), Tasa and Görgülü(2010)
Seamlessness	The degree to which the metaverse maintains its operational state in the absence of user connectivity to the digital environment	Kim et. al.(2022), Gilbert(2011), Tasa and Görgülü(2010), Guthrie et al.(2011), McKerlich et al.(2011), Noor(2010)
Concurrence	The degree to which the Metaverse platform allows for concurrent access by numerous users	Kim et. al.(2022), Cammack(2010), Gilbert(2011), Guthrie et al.(2011), McKerlich et al.(2011), Tasa and Görgülü(2010)
Economy flow	The degree to which users are able to engage in the exchange of goods or services inside the framework of the Metaverse platform	Kim et al.(2022), Cammack(2010)
Social Influence	The extent to which your use of the metaverse is influenced by the people around you	Son et al.(2014), Oh(2021), Park & Kang(2021)
Self-efficacy	Level of confidence in ability to excel at the behaviors required to use the Metaverse	Oh(2021), Park & Kang(2021), Eastin & LaRose(2000)
Perceived Enjoyment	The degree to which the utilization of the Metaverse is considered as pleasurable or entertaining	Kim et al.(2007), Oh(2021), Park & Kang(2021)
Perceived Usefulness	The extent to which Metaverse use is perceived to be useful in improving quality of life compared to before	Qiao & Han(2019), Oh(2021), Park & Kang(2021)
Perceived fee	Perceived cost of using the Metaverse, perceived irrationality of cost, and perceived dissatisfaction with cost.	Kim et al.(2007), Shin(2021)
Technicality	The degree to which you are aware of the technical elements that you need to learn to use the Metaverse, such as how to use it, how to operate it, and how proficiently to use it.	Kim et al.(2007), Shin(2021), Son et al.(2014)
Perceived Value	Perceived sacrifice of time, money, and effort to use the Metaverse versus the overall benefits of using it	Kim et al.(2007), Shin(2021)
Intention to use	The intention or plan to continue using the metaverse service in the future	Davis et al.(1989), Venkatesh et al.(2003)

The CB-SEM approach utilizes a maximum likelihood estimation (MLE) technique to estimate model coefficients with the objective of minimizing the gap between the estimated and sample covariance matrices (Hair et al., 2014). CB-SEM is suitable for studies that focus on model fit and testing the adequacy of the theoretical framework. On the other hand, Partial Least Squares Structural Equation Modeling (PLS-SEM) is a statistical technique that aims to estimate model parameters by maximizing the variation explained in endogenous variables. This approach is particularly favored in research endeavors that focus on theory creation and prediction (Hair et al., 2014).

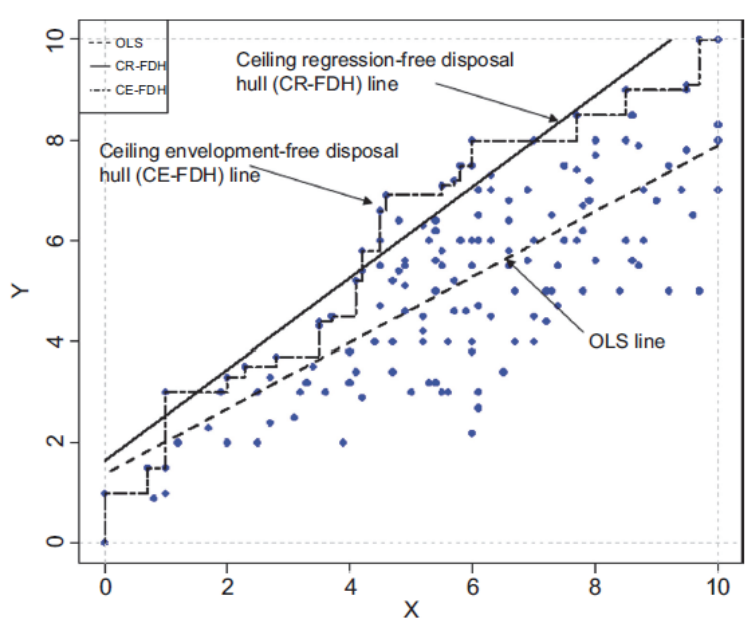
PLS path modeling is also recommended over CB-SEM for testing complex models with numerous latent variables (Henseler et al., 2009). In contrast to the mean of 4.4 latent variables seen in a CB-SEM study conducted by Shah and Goldstein (2006), our work presents a model that encompasses 13 latent variables. Furthermore, the objective of this research is to investigate the influence of Metaverse characteristics on the intention to use, with a focus on establishing a novel theoretical framework rather than merely affirming or verifying existing ideas. Based on the aforementioned justifications, it is deemed that employing a PLS path modeling approach is better suitable for conducting data analysis in the present study. According to Hair et al. (2017), a rough estimate of the sample size can be calculated as 10 times the number of variables included in the analysis, which is known as the 10-fold rule. According to this rule, the number of constructs in this study is 13 and the number of structural path is 17, so only 170 samples are needed, but 327 samples are sufficient for this study. Despite the fact that PLS-SEM has demonstrated its efficacy in analyzing small sample sizes, prior research has indicated the feasibility of employing PLS-SEM with a comparatively larger sample size of 851 participants (Anderson et al., 2011). The two-stage process, as presented by Anderson and Gerbing (1988), involved the initial validation of the measurement model, followed by the utilization of the bootstrapping technique in order to test hypotheses.

3.3.2 Necessary Condition Analysis(NCA)

NCA is a relatively new data analysis technique that helps identify necessary conditions within a data set (Dul, 2016; Dul & Goertz, 2018). It complements traditional analysis techniques like multiple regression and structural equation modeling (Dul, 2016; Dul & Goertz, 2018; Richter et al., 2020). NCA differs from those techniques by focusing on identifying regions in scatterplots that indicate the presence of required conditions, rather than analyzing average relationships between

variables. Instead of determining a linear relationship between dependent and independent variables, as done in ordinary least squares regression, NCA aims to identify a ceiling line on top of the data. This ceiling line is represented as a non-increasing stepwise linear line (step function) or a simple linear regression line.

NCA offers two main benefits to researchers. First, it generates ceiling lines and bottleneck tables that visualize and interpret the relationship between predictors and outcome variables. This helps researchers understand the minimum values or conditions required for desired outcomes. Second, NCA calculates parameters such as the accuracy of the ceiling line and the effect size of the required conditions. It also performs significance tests to ensure accurate calculations and avoid errors (Dul, 2016; Dul et al., 2020). In NCA, a Cartesian coordinate system is used to plot predictor variables on the x-axis and the resulting values of observed cases on the y-axis. An ceiling line is then drawn between the region containing the observation and the region not containing the observation. While various techniques can be used to determine the ceiling line (Dul, 2016), Figure 3 illustrates two basic ceiling lines: (1) the Ceiling Envelopment - Free Disposal Hull (CE-FDH) line, which is a non-increasing stepwise linear line (step function), and (2) the Ceiling Regression - Free Disposal Hull (CR-FDH) line, which is



〈Figure 3〉 Scatter plot with OLS and ceiling lines

a simple linear regression line through the CE-FDH line.

The ceiling line separates the space with observations from the space without observations. The larger the empty space, the greater the constraint that X imposes on Y. The ceiling line also represents the minimum level of X required to obtain a given level of Y.

Thus, the bottleneck analysis is used to further specify which predictor levels are required for different levels of the outcome. To determine the size of the hypothesized requirement, NCA uses an effect size measure. This effect size measure (d) is expressed as the ratio between the area containing the observation (S) and the area not containing the observation (C), and can be expressed as follows d = C/S. Dul (2016) also introduces a general threshold between different effect sizes d, where $0 < d < 0.1$ corresponds to a "small" effect size, $0.1 \leq d \leq 0.3$ to a "medium", $0.3 \leq d \leq 0.5$ to a "large", and $0.5 \leq d \leq 1$ to a "very large" effect size (Dul, 2016).

Following this suggestion, previous studies have used a threshold of d = 0.1 to accept the necessity hypothesis (Karwowski et al., 2016; Van Der Valk et al., 2016). However, the absolute value of d only indicates practical significance, i.e., the significance of the effect size from a practical perspective. Therefore, NCA allows researchers to assess the statistical significance of the necessity effect size calculated by the permutation test, which is also taken into account when establishing the necessity hypothesis (Dul et al., 2020).

Therefore, in order to claim that a condition is a necessary condition, it must meet three main criteria: i) it must have a theoretical justification, ii) the effect size d must be greater than 0, and iii) the condition must have a small p-value in a significance test (e.g., $p < .05$) (Dul et al., 2020).

Ⅳ. Results

4.1 Measurement Validation

The measurement model was evaluated by examining internal consistency, convergent validity, and discriminant validity. Convergent validity pertains to the examination of the relationship between various measurements and a shared conceptual construct (Dinev & Hart, 2004). 〈Table 3〉 shows that all thirteen constructs met the required thresholds as Composite Reliability was above 0.7 and Average Variance Extracted exceeded 0.5 (Hair et al., 2014). According to Fornell and Larcker (1981), Cronbach's Alpha, a measure used to assess internal consistency, exceeded the threshold of 0.7. Thus, the convergent validity of the constructs was established.

The Fornell-Larcker and Heterotrait-Monotrait criteria were examined to test the discriminant

〈Table 3〉 Cronbach's Alpha, composite reliability, and average variance extracted of constructs

Construct	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Telepresence	0.806	0.885	0.721
Interoperability	0.842	0.894	0.678
Seamlessness	0.785	0.845	0.580
Concurrence	0.726	0.845	0.646
Economy flow	0.839	0.901	0.752
Perceived Usefulness	0.810	0.875	0.637
Perceived Enjoyment	0.867	0.910	0.716
Technicality	0.914	0.939	0.795
Perceived Fee	0.760	0.819	0.608
Perceived Value	0.875	0.923	0.801
Social Influence	0.730	0.847	0.648
Self-efficacy	0.809	0.887	0.723
Intention to Use	0.861	0.915	0.782

validity. Discriminant validity refers to the degree to which a measurement effectively distinguishes itself from other constructs within the nomological network (Dinev & Hart, 2004). 〈Table 4〉 depicts the Fornell-Larcker criterion in which the square roots of Average Variance Extracted from the constructs were Concurrence (0.804), Economy flow (0.867), Perceived Enjoyment (0.846), Perceived Fee (0.780), Intention to Use (0.884), Interoperability (0.823), Seamlessness (0.761), Self-efficacy (0.850), Social Influence (0.805), Technicality (0.892), Telepresence (0.849), Perceived Usefulness (0.798), and Perceived Value (0.895), which were higher than the correlation values between each construct as well as all other constructs. Therefore, discriminant validity was established according to the Fornell-Larcker criterion. 〈Table 5〉 shows the Heterotrait-Monotrait ratio of the constructs, and since all the constructs had HTMT less than 0.9 (Henseler et al., 2015), the measurement model's discriminant validity was established.

Next, the R2 value was evaluated. Metaverse attributes accounted for 47.5% of the explained variance for Perceived Usefulness and 38.1% of the explained variance for Perceived Enjoyment. Also, Perceived Usefulness, Perceived Enjoyment, Technicality and Perceived Fee accounted for 37.0% of the explained variance for Perceived Value. In addition, Perceived Value, Social Influence and Self-efficacy represented 48.0% of the explained variance for Intention to Use.

〈Table 4〉 Discriminant validity - Fornell-Larcker criterion

	1	2	3	4	5	6	7	8	9	10	11	12	13
concurrence	**0.804**												
economy flow	0.504	**0.867**											
enjoyment	0.503	0.345	**0.846**										
perceived fee	0.092	0.288	0.109	**0.780**									
intention to use	0.481	0.380	0.687	0.124	**0.884**								
interoperability	0.643	0.473	0.518	0.069	0.547	**0.823**							
seamlessness	0.299	0.130	0.099	0.154	0.121	0.143	**0.761**						
self-efficacy	0.367	0.284	0.337	0.113	0.356	0.406	0.134	**0.850**					
social influence	0.373	0.393	0.349	0.393	0.515	0.426	0.185	0.292	**0.805**				
technicality	-0.010	0.203	-0.037	0.567	-0.018	0.007	0.137	-0.027	0.302	**0.892**			
telepresence	0.435	0.355	0.494	0.257	0.533	0.496	0.266	0.282	0.481	0.170	**0.849**		
usefulness	0.519	0.444	0.663	0.224	0.678	0.622	0.127	0.405	0.543	0.144	0.524	**0.798**	
perceived value	0.399	0.411	0.539	0.194	0.648	0.495	0.102	0.303	0.525	0.183	0.412	0.535	**0.895**

〈Table 5〉 Discriminant validity - Heterotrait-Monotrait criterion

	1	2	3	4	5	6	7	8	9	10	11	12	13
concurrence													
economy flow	0.639												
enjoyment	0.634	0.394											
perceived fee	0.140	0.311	0.135										
intention	0.609	0.431	0.796	0.106									
interoperability	0.822	0.548	0.604	0.081	0.641								
seamless	0.390	0.163	0.110	0.224	0.130	0.188							
self-efficacy	0.472	0.342	0.397	0.138	0.422	0.491	0.196						
social influence	0.508	0.490	0.431	0.480	0.641	0.537	0.256	0.381					
technicality	0.081	0.237	0.121	0.628	0.074	0.063	0.164	0.063	0.382				
telepresence	0.569	0.431	0.588	0.283	0.639	0.602	0.340	0.348	0.632	0.202			
usefulness	0.673	0.517	0.798	0.256	0.810	0.750	0.144	0.502	0.695	0.162	0.650		
perceived value	0.500	0.472	0.616	0.171	0.744	0.577	0.122	0.361	0.655	0.202	0.490	0.631	

4.2 PLS Path Modeling and Hypotheses Testing

Prior to conducting the evaluation of the structural model, it is necessary to assess the presence of multicollinearity in order to ascertain the validity of the obtained results. According to Hair and Lukas (2014), the Variance Inflation Factor (VIF) values observed in the model were all below 5, ranging

from 1.351 to 3.601. This suggests that there is no evidence of multicollinearity present in the model. Subsequently, the structural model underwent evaluation by the bootstrapping technique, employing 5,000 resamples, in order to ascertain the statistical significance of the hypotheses (refer to 〈Table 6〉).

Almost all hypotheses related to VAM were supported. Hypothesis 1~2 were supported, revealing that Perceived Usefulness (β =0.268, t=3.459, p=0.001) and Perceived Enjoyment (β =0.366, t=5.186, p=0.000) were positively associated with Perceived Value. Hypothesis 5 was supported, indicating that Perceived Value (β =0.491, t=9.140, p=0.000) was positively related to Intention to Use. However, Hypothesis 3~4 were not supported, indicating that Technicality (β =0.154, t=2.530, p=0.011) and Perceived Fee (β =0.007, t=0.097, p=0.923) were not negatively related to Perceived Value.

Hypotheses about the effects of Metaverse characteristics on Perceived Usefulness and Perceived Enjoyment were partially supported and partially rejected. The results show that Telepresence was positively associated with Perceived Usefulness (β =0.259, t=5.213, p=0.000) and Perceived Enjoyment (β =0.294, t=5.235, p=0.000). Interoperability had a significant effect on Perceived Usefulness (β =

〈Table 6〉 Results of hypothesis testing

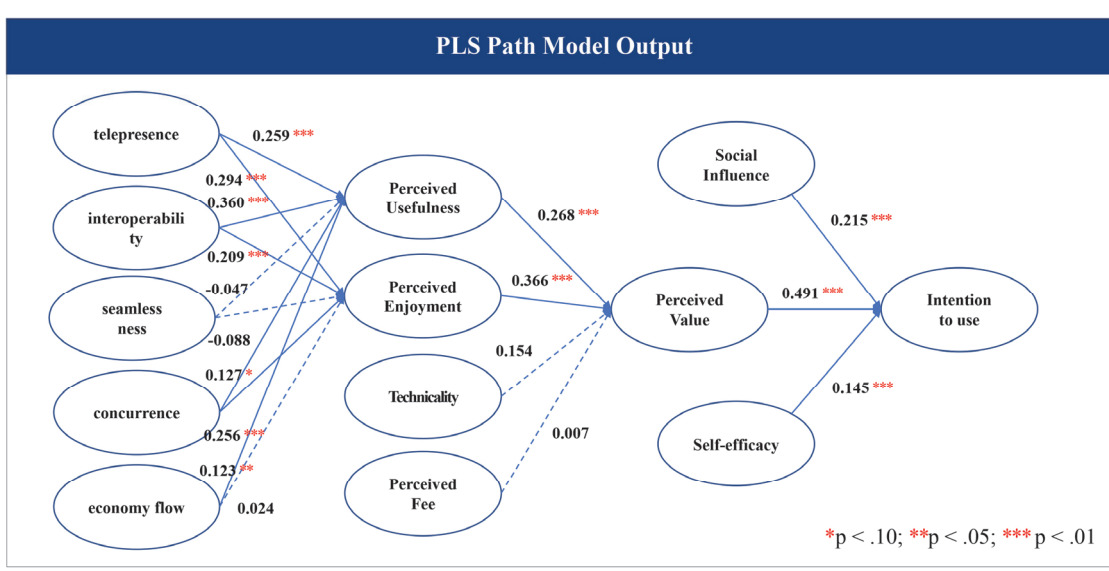
Hypothesis	Path	β	s.e.	t-value	p-value	Result
H1	usefulness → value	0.268	0.078	3.459	0.001	Supported
H2	enjoyment → value	0.366	0.071	5.186	0.000	Supported
H3	technicality → value	0.154	0.061	2.530	0.011	Not Supported
H4	fee → value	0.007	0.071	0.097	0.923	Not Supported
H5	value → intention	0.491	0.054	9.140	0.000	Supported
H6	telepresence → usefulness	0.259	0.050	5.213	0.000	Supported
H7	telepresence → enjoyment	0.294	0.056	5.235	0.000	Supported
H8	interoperability → usefulness	0.360	0.052	6.944	0.000	Supported
H9	interoperability → enjoyment	0.209	0.077	2.703	0.007	Supported
H10	seamless → usefulness	-0.047	0.070	0.671	0.502	Not Supported
H11	seamless → enjoyment	-0.088	0.063	1.403	0.161	Not Supported
H12	concurrence → usefulness	0.127	0.073	1.743	0.081	Supported
H13	concurrence → enjoyment	0.256	0.075	3.390	0.001	Supported
H14	economy flow → usefulness	0.123	0.054	2.278	0.023	Supported
H15	economy flow → enjoyment	0.024	0.064	0.377	0.706	Not Supported
H16	social influence → intention	0.215	0.053	4.020	0.000	Supported
H17	self-efficacy → intention	0.145	0.045	3.243	0.001	Supported

0.360, t=6.944, p=0.000) and Perceived Enjoyment (β =0.209, t=2.703, p=0.007). Concurrence was also positively associated with Perceived Usefulness (β =0.127, t=1.743, p=0.081) and Perceived Enjoyment (β =0.256, t=3.390, p=0.001). Meanwhile, Seamlessness was not positively related to Perceived Usefulness (β =-0.047, t=0.671, p=0.522) and Perceived Enjoyment (β =-0.088, t=1.403, p=0.161). On the other hand, Economy Flow had a significant effect on Perceived Usefulness (β =0.123, t=2.278, p=.023), but not on Perceived Enjoyment (β =.024, t=0.377, p=0.706). Therefore, H6, H7, H8, H9, H12, H13 and H14 were supported but H10, H11 and H15 were not supported.

Meanwhile, Hypothesis 16 and 17 were supported, indicating that Social Influence (β =0.215, t=4.020, p=0.000) and Self-efficacy (β =0.145, t=3.243, p=0.001) were positively related to Intention to Use.

4.3 NCA

To further explore the relationship between Metaverse attributes and perceived usefulness and perceived enjoyment, we complemented PLS-SEM with Necessary Condition Analysis (NCA). Following the guidelines of Richter et al. (2020), we used the latent variable scores of the Metaverse attributes, perceived usefulness and perceived enjoyment, obtained using PLS-SEM, as a starting point when performing NCA. We imported these scores into



〈Figure 4〉 Partial Least Squares (PLS) Output

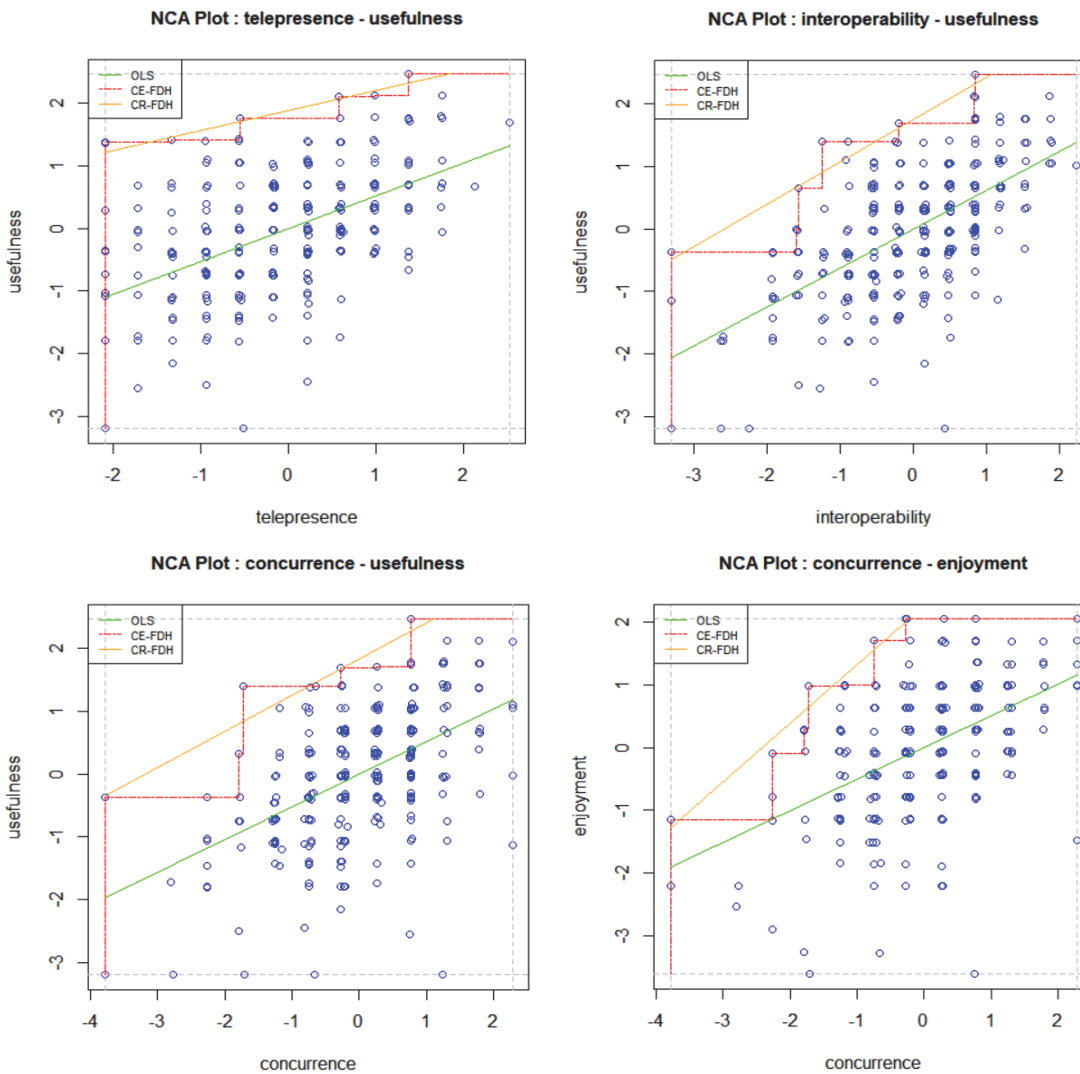
the R software and followed the steps described in the quick start guide for running NCA (Dul, 2021). In order to keep our analysis from inferring additional linear assumptions, between the predictor and the outcome variables, we used the ceiling envelopment-free disposal hull (CE-FDH) line and the ceiling regression-free disposal hull (CR-FDH). This ceiling line also indicates the minimum level of a particular Metaverse attribute that is required to achieve a given level of perceived usefulness and perceived enjoyment (see 〈Figure 5〉). Furthermore, 〈Figure 5〉 also shows a ceiling regression - free disposal hull (CR-FDH), which can be used when there are many levels within the data, and when it can be considered continuous. The 〈figure 5〉 also displays an OLS regression line running through the middle of the data as a reference point.

4.3.1 Effect size and significance testing

First, we examined the effect sizes (d) of the latent variable scores, testing their statistical significance using a recommended random sample size of 10,000 (Dul, 2016; 64 Dul et al., 2020; Dul, 2021). According to Dul and colleagues (Dul et al., 2020), in order for a condition to be considered necessary, it must meet three criteria: i) theoretical justification, ii) effect size d 〉 0, and iii) a small p value (p 〈.05). The NCA results (see 〈Table 7〉) indicate that telepresence, interoperability and concurrence are necessary conditions for perceived usefulness. Specifically, telepresence, interoperability and concurrence are necessary for perceived usefulness, showing a small to medium effect size (d = 0.104, 0.237, 0.237) (Dul, 2016), which is statistically significant (p 〈.01) (Dul, 2021). Furthermore, the NCA results (see 〈Table 7〉) indicate that concurrence is the only necessary condition for perceived enjoyment. Concurrence is necessary for perceived enjoyment, showing a small to medium effect size (d = 0.209) (Dul, 2016), which is statistically significant (p 〈 .01) (Dul, 2021).

〈Table 7〉 Ceiling Line Effect

Perceived usefulness	CE-FDH		CR-FDH		Perceived enjoyment	CE-FDH		CR-FDH	
	d	p	d	p		d	p	d	p
telepresence	0.104	0.002	0.093	0.001	telepresence	0.030	0.191	0.015	0.286
interoperability	0.237	0.000	0.207	0.000	interoperability	0.074	0.230	0.048	0.356
seamlessness	0.115	0.142	0.107	0.124	seamlessness	0.019	0.906	0.009	0.911
concurrence	0.237	0.001	0.200	0.003	concurrence	0.209	0.000	0.173	0.000
economy flow	0.118	0.181	0.110	0.104	economy flow	0.060	0.394	0.040	0.449



〈Figure 5〉 NCA Plot

4.3.2 Bottleneck analysis

Next, in order to provide further details, we performed a bottleneck analysis (see 〈Table 8〉). For each desired outcome variable (perceived usefulness, perceived enjoyment) in the first column, Table 10 shows the minimum values required for the predictor variables (telepresence, interoperability, seamlessness, concurrence and economy flow) in the following columns.

According to 〈Table 8〉, in order to reach a medium-to-high level of usefulness (50%), four necessary conditions need to be in place: interoperability at least 5.5%, seamlessness at least 0.6%, concurrence at least 3.4% and economy flow at least 0.9%. On the other hand, a high level of usefulness (100%) requires five necessary conditions to be met: telepresence at a minimum of 88.9%, interoperability at a minimum of 70.6%, seamlessness at a minimum of 85.9%, concurrence at a minimum of 67.6% and economy flow at a minimum of 47.4%.

In addition, in order to reach a medium-to-high level of enjoyment (50%), one necessary condition needs to be in place: concurrence at no less than 1.2%. Whereas, for a high level of enjoyment (100%), five necessary conditions need to be in place: telepresence at no less than 8.3%, interoperability at no less than 13.5%, seamlessness at no less than 11.9%, concurrence at no less than 31.2% and economy flow at no less than 3.1%.

〈Table 8〉 Bottleneck Table (percentage)

usefulness	telepresence	interoperability	seamlessness	concurrence	economy flow
0.00%	NN	NN	NN	NN	NN
10.00%	NN	NN	NN	NN	NN
20.00%	NN	NN	NN	NN	NN
30.00%	NN	NN	NN	NN	NN
40.00%	NN	NN	NN	NN	NN
50.00%	NN	5.505	0.612	3.364	0.917
60.00%	NN	7.034	0.612	3.364	0.917
70.00%	NN	10.092	0.612	5.199	2.752
80.00%	NN	10.092	0.612	5.199	3.058
90.00%	63.609	70.031	26.300	67.584	3.058
100.00%	88.991	70.642	85.933	67.584	47.401
enjoyment	telepresence	interoperability	seamlessness	concurrence	economy flow
0.00%	NN	NN	NN	NN	NN
10.00%	NN	NN	NN	NN	NN
20.00%	NN	NN	NN	NN	NN
30.00%	NN	NN	NN	NN	NN
40.00%	NN	NN	NN	NN	NN
50.00%	NN	NN	NN	1.223	NN
60.00%	NN	NN	NN	1.223	NN
70.00%	NN	NN	NN	5.199	0.917
80.00%	NN	2.752	NN	5.199	0.917
90.00%	8.257	2.752	NN	15.291	3.058
100.00%	8.257	13.456	11.927	31.193	3.058

Ⅴ. Conclusion

5.1 Discussion

This study examines the factors that influence the intention to use Metaverse by applying the Extended Value-based Adoption Model (EVAM). The recent non-face-to-face daily life and rapid digital transformation caused by the COVID-19 pandemic have ushered in the era of Metaverse, a virtual world based on scalability beyond space and time constraints and a sense of reality similar to the real world (Lee, 2021). Nevertheless, the introduction of novel platforms like Metaverse does not automatically result in widespread dissemination due to user approval and adoption. The delay in popularization can be attributed to user rejection and resistance to innovation (Choi et al., 2017). Hence, in order to ensure the stable acceptance and proliferation of emerging platforms like Metaverse, it is imperative to thoroughly investigate and study the elements that influence users′ intention to adopt and utilize Metaverse right from its earliest stage of acceptance and diffusion.

This empirical study examined the impact of various adoption factors on the intention to use the Metaverse using the Extended Value-based Adoption Model (EVAM). The factors influencing the intention to use the Metaverse were categorized as Metaverse characteristics, including Telepresence, Interoperability, Seamlessness, Concurrence, and Economy Flow, as well as personal characteristics, such as Social Influence and Self-efficacy. These factors were assessed using a structural equation model. We also conducted a necessary condition analysis to determine whether Metaverse characteristics were necessary for perceived usefulness and perceived enjoyment. The results are as follow.

First, Perceived Usefulness and Perceived Enjoyment were found to have a positive effect on Perceived Value. These results were consistent with most existing studies(Kim et. al, 2007; Lee et. al, 2021, Shin, 2021). These results suggest that the more people perceive the Metaverse as useful and fun, the more valuable they find it to them. In addition, Perceived Value was found to have a positive effect on the intention to use the Metaverse. It was found that the value was formed and the intention to use it increased. On the other hand, Technicality and Perceived Fee did not have a statistically significant negative effect on Perceived Value. Many previous studies hypothesized that technicality would have a negative effect on perceived value and found a positive effect (Kim et. al, 2007; Lee et. al, 2021, Shin, 2021). The reason for these findings is that Metaverse is hedonic in nature, and because its users are mostly young or early adopters, they may feel that learning and

using Metaverse is worth the effort, even if it is difficult. And, although not statistically significant, they feel that it is worth the cost of using Metaverse.

Second, among the Metaverse characteristics, Telepresence, Interoperability, Concurrence and Economy Flow were found to have a positive impact on Perceived Usefulness, and Telepresence, Interoperability and Concurrence were found to have a positive impact on Perceived Enjoyment.

Telepresence refers to the sensation of being present in a real environment, even when physically separated from it. The concept of telepresence is crucial for platforms aiming to create a similar and immersive experience that can compensate for the lack of physical contact in virtual environments. By enhancing the sense of immersion, telepresence plays a vital role in bridging the gap between the user and the digital world (Davis et al., 2009; Tasa & Görgülü, 2010; Kim et al., 2022). Our findings were consistent with previous studies in which telepresence positively influenced perceived usefulness and perceived enjoyment(Lee et al., 2021; Shin, 2021; Han & Ahn, 2019). The higher this sense of telepresence, the more useful and fun the Metaverse platform was found to be. However, a certain level (see NCA bottleneck tables) of the exogenous construct is necessary for the outcome to manifest.

Interoperability pertains to the establishment of a connection between data and information in both the physical realm and the Metaverse. This connection enables the outcomes of user experiences and actions within the Metaverse to be linked to the real world. Consequently, the user's experience within the Metaverse is enhanced and made more convenient by leveraging lifelogging information obtained from the physical world. According to McMillan and Hwang (2002), there is a favorable correlation between a user's perception of interoperability inside a certain system and their views towards the technology. Our findings were consistent with previous studies in which interoperability positively increased perceived usefulness and perceived ease of use(Cha, 2019; Shin, 2021). The higher this interoperability, the more useful and fun the Metaverse platform was found to be.

Concurrence refers to the ability of a platform to accommodate multiple users simultaneously. In the real world, information creation and expansion often occur within large groups where people share diverse information. Therefore, for a platform to hold value, it is essential to have a substantial user base (Kim et al., 2022). It has been found that the degree of concurrence directly influences the perceived usefulness and enjoyment of using the Metaverse platform. The more concurrent the platform is, meaning the more users it can accommodate concurrently, the more valuable and engaging the user experience becomes within

the Metaverse. This is because increased concurrence fosters social interactions, information sharing, and a sense of community, which enhance the overall utility and enjoyment of the platform.

Economy flow refers to the presence of tradeable products or services within the platform. It involves the diversity of transactions that can take place, which in turn increases the user's immersion and engagement within the platform. The concept of economy flow suggests that the availability of various economic activities and exchanges enhances the overall user experience and utility of the Metaverse platform. The more economy flows there are, meaning the more opportunities for trade and transactions, the more valuable and useful the platform becomes. This is because a vibrant economy within the Metaverse stimulates user participation, interaction, and investment, thereby enriching the user's time spent within the platform.

Third, The NCA results indicate that telepresence, interoperability, and concurrence are necessary conditions for perceived usefulness, while concurrence is the only necessary condition for perceived enjoyment.

These minimum values indicate the threshold that each predictor variable needs to meet in order to achieve the desired level of usefulness or enjoyment. For example, to reach a medium-to-high level of usefulness, a Metaverse company must ensure that interoperability is at least 5.5%, seamlessness is at least 0.6%, concurrence is at least 3.4%, and economy flow is at least 0.9%. Similarly, to achieve a high level of usefulness, the company needs to meet the higher thresholds for each variable, such as having telepresence at a minimum of 88.9%, interoperability at a minimum of 70.6%, seamlessness at a minimum of 85.9%, concurrence at a minimum of 67.6%, and economy flow at a minimum of 47.4%.

For enjoyment, the analysis indicates that a medium-to-high level (50%) requires concurrence to be at least 1.2%. A high level of enjoyment (100%) necessitates meeting the higher thresholds for telepresence, interoperability, seamlessness, concurrence, and economy flow.

Finally, we found that Social Influence had a positive effect on Intention to Use the Metaverse. We found that the results are consistent with previous studies that social influence affects usage intention (Venkatesh et al., 2003; Choi et al., 2017; Oh, 2021). The findings indicate that individuals are more likely to see the Metaverse as useful and express a higher intention to utilize it when they observe a good perception of the Metaverse among their social circle. This suggests a significant social influence on individuals' beliefs and intentions about the utilization of the Metaverse. In addition, Self-efficacy had a static effect on the Intention to Use the

Metaverse. These results are consistent with previous research showing that self-efficacy affects usage intention (Choi et al., 2017; Oh, 2021). This result suggested that the higher the self-efficacy, the higher the willingness to use the Metaverse, as shown in 〈Figure 4〉.

5.2 Theoretical and managerial implications

The theoretical implications of this study are as follows.

First, because Metaverse research is currently in its infancy, much of the research on Metaverse is conceptual and typological; however, this study provides a foundation for empirical Metaverse research by examining its impact on Metaverse acceptance through actual Metaverse users.

Second, this study aims to investigate the determinants of intention to adopt Metaverse among current users, considering the current stage of Metaverse technology development. The factors influencing adoption intention are analyzed by categorizing them into two main dimensions: technology characteristics (telepresence, interoperability, seamlessness, concurrence, and economy flow) and personal characteristics (social influence and self-efficacy).

Third, while there have been studies on user acceptance of telepresence, interoperability, etc. in existing AR-VR studies, there have been no studies on Metaverse user acceptance of the five Metaverse characteristics used in this study.

Finally, this study demonstrates how PLS-SEM and NCA are complementary when the research goal is to explore Metaverse attributes that are important for high usefulness and enjoyment. This provides guidance for researchers who wish to apply these methods to develop further explanations of Metaverse acceptability. Therefore, one contribution could be to encourage and guide researchers to adopt a complementary approach by combining PLS-SEM and NCA appropriately when investigating the acceptance of Metaverses.

Based on the research findings that Telepresence, Interoperability, Concurrence, and Economy Flow have a positive impact on Perceived Usefulness in the Metaverse, and Telepresence, Interoperability, and Concurrence have a positive impact on Perceived Enjoyment, Metaverse companies can leverage these results to enhance its offerings and improve user satisfaction. Here's a more detailed explanation of how each characteristic can be utilized.

First, to improve telepresence, metaverse companies should develop immersive technologies such as virtual reality (VR) and augmented reality (AR) to create a sense of presence in the virtual environment. They should also implement realistic and interactive elements within the metaverse to enhance the feeling of being in the real world. To do this,

they should look to the success of VR platforms such as Oculus Quest and HTC Vive in delivering immersive experiences and applying similar technologies to metaverse development.

Second, to promote interoperability, metaverse companies need to build seamless integration between the metaverse and the real world to enable data and information exchange. They also need to enable cross-platform compatibility so that users can access and interact with the metaverse from a variety of devices. To do this, they should study interoperable platforms such as Roblox, which allows users to create and share content on a variety of devices and operating systems.

Third, to promote concurrence, metaverse companies need to build a large user base to encourage social interaction, information sharing, and community building within the metaverse. They also need to provide features and incentives that promote collaboration and cooperation among users. To do this, they should look to the success of multiplayer games like Fortnite and Minecraft, where large communities engage in shared experiences, and apply similar mechanisms to promote concurrence in the metaverse.

Fourth, to facilitate economy flow, metaverse companies will need to integrate a virtual currency or token system to enable trading and transactions within the metaverse. They will also need to create marketplaces where users can buy, sell, and trade virtual assets and services. To do this, they should investigate the success of blockchain-based platforms like Decentraland, which allows users to buy and sell virtual land and assets, and explore integrating similar economic systems.

By prioritizing and incorporating these characteristics into their Metaverse platform, a company can enhance the perceived usefulness and enjoyment of its users. This, in turn, can lead to increased user adoption, engagement, and loyalty, ultimately benefiting the company's success in the Metaverse. Additionally, the company can use these research findings as a basis for further innovation, continually refining and expanding their offerings to align with user preferences and needs in the evolving Metaverse landscape.

5.3 Limitations and future research

This section lists some limitations of this study that should be taken into account.

First, since the sample consisted of users who have used the Metaverse platform, it would be useful to study adoption resistance among non-users of the Metaverse platform in the future.

Second, it is worth noting that while the primary focus of this study was the desire to use Metaverse, it would have been more comprehensive to also inquire about the intention to continue using Metaverse, given that the survey targeted those who were already users

of the platform.

Third, the present study was conducted utilizing the value-based adoption model. However, it is recommended that future research endeavors incorporate supplementary validation efforts by employing alternative acceptance models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Expectancy Confirmation Model.

Fourth, the metaverse has various technical characteristics such as telepresence, interoperability, seamlessness, concurrence, and economy flow, and personal characteristics such as social influence and self-efficacy, but this study covered five technical factors and two personal factors by synthesizing previous research on value-based adoption model and the characteristics of the metaverse. Therefore, the research model itself is somewhat complicated, and it would be good to analyze it again with a research model that excludes unnecessary variables through NCA(Necessary Condition Analysis) in the next study.

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