The Adoption of Metaverse in the Retail Industry and its Impact on Sustainable Competitive Advantage: Moderating Impact of Sustainability Commitment

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Abstract. The concept of the metaverse involves creating a fully immersive virtual world that allows users to interact with each other and digital objects in a way that is almost indistinguishable from reality. One of the key areas where the metaverse is expected to have an impact is retailing. Although there have been several studies on the use of the metaverse in different industries, this issue is rarely investigated in previous studies in the context of retail companies focusing on users' perceptions. This study accordingly explores the factors impacting the adoption of a metaverse in the retail industry and develops a new model based on the Resource-Based View (RBV) theory. In addition, the relationship between the usage intention of the metaverse and product innovation, and the relationship between product innovation and sustainable competitive advantage are investigated. Furthermore, as sustainability is a critical issue in the adoption of innovation by industries, this study aims to further investigate whether sustainability commitment will strengthen the impact of attitude toward metaverse on the intention to use. The data was collected from retail companies in Malaysia and analyzed to evaluate the proposed research model. The outcomes of this research indicated that there is a positive impact of product innovation on sustainable competitive advantage through the adoption of a metaverse in retail companies. In addition, our findings stressed that the intention to use metaverse will lead to product innovation in retail companies. Furthermore, the results revealed that sustainability commitment does not moderate the relationship between attitude toward the metaverse and intention to use, but impacts the usage intention of the metaverse directly.

Keywords: Metaverse, Resource-Based View, Sustainability Commitment, Competitive Advantage, Retail Industry

1. Introduction

In recent years, the trend of digitization has been evident in various fields, including business (Broccardo et al., 2023), entertainment (Hennig-Thurau et al., 2021), education (Dwivedi, Kshetri, Hughes, Slade, et al., 2023; Dwivedi, Pandey, et al., 2023), and more (Cantú-Ortiz et al., 2020; Hew et al., 2020; Kshetri & Dwivedi, 2023). Digitization has been used as a means of improving efficiency and accessibility (Limarenko et al., 2023), allowing users to access services online with greater ease (Akram et al., 2021; Amit & Han, 2017; Gupta et al., 2021). Consumer habits are changing dramatically in the digital age (Latinovic & Chatterjee, 2019), as people increasingly use online channels to interact with brands and make purchases (Nazir et al., 2023). A variety of factors are driving this shift, including the convenience and accessibility of digital channels (Ozili, 2018), the rise of e-commerce (Lai et al., 2014), and the increasing importance of digital technologies in everyday life (Plowman, 2016). Firms are investing heavily in digital platforms and technologies that support digital environments in response to these changes. This includes the advancement of virtual reality and augmented reality technologies (Kozinets, 2023), which provide consumers with new immersive and engaging ways to interact with products and brands.

At the same time, the evolution of these digital environments contributes to the emergence of the metaverse, a hyper-connected digital universe (Ersoy & Gürfidan, 2023; Hollensen et al., 2022; Mogaji et al., 2023). The metaverse is a networked space of virtual realities (Deveci, Pamucar, et al., 2022; Dwivedi et al., 2022; Koohang et al., 2023a; Pamucar et al., 2023) that enables consumers, brands, and businesses to transact and interact in novel ways (Arya et al., 2023; Joy et al., 2022; Tan et al., 2023; Yoo et al., 2023). It goes beyond traditional virtual reality experiences by connecting multiple virtual worlds and enabling seamless navigation between them (Dwivedi et al., 2022; Far et al., 2023). Metaverse phrase, which is a combination of the terms "meta"

(meaning beyond) and "verse" (meaning a configuration of time and space), refers to something completely distinct. This is very dissimilar from the universe, which holds that space and time are always organized in a comparable way (uni) at every given time. In contrast, the metaverse denotes that either the space or the time will be different at a specific point in time (Marabelli & Newell, 2023). The metaverse offers a wide range of possibilities for users (Allam et al., 2022), including virtual commerce, education, gaming, social interaction, and more. By embracing the metaverse, businesses can stay at the forefront of technological advancements and meet the evolving expectations of their customers.

One of the key areas where the metaverse is expected to have an impact is retailing (Yoo et al., 2023). In the metaverse, consumers can navigate through virtual environments that are designed to replicate real-world shopping experiences, but with added layers of interactivity and immersion (Yoo et al., 2023). This provides customers with an interesting and memorable shopping experience that can be tailored to each customer's specific tastes (Han et al., 2022). Metaverse retailing also allows more collaboration between retailers and consumers, as well as between consumers themselves. It also enables diverse innovative capabilities, including virtual product demonstrations, collaborative shopping experiences, or even user-generated content creation. By enabling these types of interactions, the metaverse is expected to create new opportunities for retailers to engage with consumers and build stronger relationships with them. The potential impact of the metaverse on society and the economy is enormous (Bibri et al., 2022). It can transform the way we work, learn, socialize, and consume media, creating new opportunities for businesses and entrepreneurs to reach audiences in new and innovative ways. The metaverse has also the potential to offer a much more personalized and customized user experience (Buhalis et al., 2022), enabling businesses and service providers to offer more tailored experiences to their customers, thereby improving the overall quality of service.

These advantages have opened new venues for the metaverse's adoption and implementation with promising growth ratios in the business share. Based on the portion of the virtual business that changes to the metaverse and based on the business growth, the estimated metaverse market opportunity ranges between 3.75 trillion US dollars to 12.46 trillion US dollars (Statista, 2022d). The metaverse is considered to be the next generation of the internet, in which the digital and physical universes collide. The metaverse is likely to be an important area of innovation and development in the coming years, with home-related products (8.44%), automobiles (8.5%), and real estate (30.4%) accounting for the majority of the metaverse market’s potential overall consumer expenditure in the USA (Statista, 2022c). According to a survey done in late 2021, the main advantage of the metaverse was recognized as transcending real-life barriers. Improving imaginative thinking and creativity came in second, with 37% of those surveyed citing it as an advantage. Furthermore, the metaverse offers options for education, upskilling, and exploring new professional paths (Statista, 2022b).

While it is in its early stages of development, the potential for the metaverse; as an essential enabler of the current digital transformation growth (Chakraborty & Kar, 2022), to transform social and economic activity is significant. The metaverse offers an envisaged future that opens a venue for consideration in the context of future research, notably focusing on the examination of humans' leading position in the construction of its potential (Antón et al., 2023). This can be explained as the metaverse was created and iterated into an online 3D social networking platform with fresh and innovative user experiences in the online realm (Dwivedi, Hughes, et al., 2023; Kar & Varsha, 2023). Users of the metaverse must adapt and become more digitally sophisticated, mature, and amenable to connecting with their surroundings through various communication and media

avenues. There are many factors impacting the intention to use the metaverse. However, these factors are rarely explored and examined in previous studies.

In fact, while the potential benefits of the metaverse are numerous, there are also significant concerns about privacy and security that must be addressed (Fernandez & Hui, 2022), an issue that has been linked with virtual systems in previous literature (Lata & Singh, 2022). According to Statista (2022a), 87% of respondents in the United States are concerned about their privacy if Facebook succeeds in constructing the metaverse. Furthermore, 50% of all participants expressed concern that hackers would be able to easily mimic others. In addition, 41% of those surveyed believed it would be too difficult to safeguard their real identities in the metaverse.

Metaverse has ambiguous impacts on the three pillars of sustainability. The three fundamental dimensions of sustainability are economic, environmental, and social sustainability (Arpaci et al., 2022). Corporate sustainability strategies that stress environmental sustainability dimensions are being adopted by organizations more frequently (Malesios et al., 2020). As a consequence, the trend of converting conventional supply chains into green supply chains is growing. The requirement to match supply chain models and corporate processes with sustainable practices is what is driving this transition (Ali et al., 2022). Sustainable business management under a Circular Economy (CE) in the metaverse involves combining the principles of a CE with the unique opportunities and challenges presented by the digital metaverse. In fact, improving sustainable business through CE in the metaverse entails incorporating CE principles into digital business practices to reduce waste and generate value for both customers and the environment. Metaverse is a digital world that can be used to promote the principles of sustainability (Pamucar et al., 2022) and accordingly CE. According to Umar (2022), the metaverse opens several routes for accelerating the implementation of Sustainable Development Goals (SDGs). However, a limited number of studies have investigated metaverse adoption in the context of sustainability dimensions. In the context of economic sustainability, in the study by Koohang et al. (2023b), the authors examined the potential impacts of the metaverse on the economy, including customer experience, virtual goods, and marketing. In the context of social sustainability, the work by Arpaci et al. (2022) examined social sustainability in relation to metaverse adoption and the degree to which the metaverse's psychological and social impacts will. According to the authors, the social sustainability of the metaverse can be defined as the level to which social challenges are approached by the metaverse. On the other hand, less research has focused on the impact of the metaverse adoption on the environmental dimension of the sustainability.

Based on the above discussion, it is important to know what factors impact the attitude toward metaverse in retailing companies and whether the adoption of the metaverse will have an impact on product innovation and sustainable competitive advantage. Therefore, as sustainability is a critical issue in the adoption of new innovation by industries (Nilashi, Keng Boon, et al., 2023), this study aims to further investigate whether sustainability commitment will strengthen the impact of attitude toward metaverse on the intention to use. These issues are fairly uninvestigated in the previous research in the context of metaverse and retailing. A model is developed based on the Resource-Based View (RBV) (Lockett & Thompson, 2001; Lockett et al., 2009) to investigate the relationship between the explored factors and attitude toward metaverse, the relationship between attitude toward metaverse and intention to use, the relationship between intention to use of metaverse and product innovation, and the relationship between product innovation and sustainable competitive advantage.

The remainder of this paper is organized as follows. The theoretical background is presented in Section 2. In Section 3, a literature review on the metaverse is presented. In Section 4, the

hypotheses and the model are developed. In Section 5, the data collection and analysis are presented. In Section 6, discussions on the results are presented. In Section 7, we present the research implications. Finally, the conclusion, limitations, and future research are presented in Section 8.

2. Resource-Based View (RBV)

The RBV has become a preeminent theoretical framework in the strategy and business fields during the past forty years and has been explored in several research articles in different contexts (C. Cooper et al., 2023; Münch et al., 2022; Ozdemir et al., 2023; Patnaik et al., 2022). Despite the fact that the original emergence of the concepts underlying the RBV is attributed to Penrose (2009), which stressed the importance of the assets of a company, notably its management resources, as the main forces behind its development; scholars began to pay attention to these features in the 1980s, particularly as a challenge to the prevalent industry-based paradigm. In particular, the RBV promotes making the best use of company assets to improve productivity through sustained competitive advantage. RBV has been used in a variety of academic disciplines over the past three decades, including organizations' planning, innovation adoption, cooperation, global business, and knowledge governance. Following this, it has been broadened and emphasized in a variety of resources' adoption studies, including the utilization of assets, abilities, information, competencies, and procedures that, due to their uniqueness, can result in gaining a competitive edge and enhance the company's performance (S. C. Cooper et al., 2023). RBV generally investigates the connection between a company's resources and performance (Branco & Rodrigues, 2006), which makes it suitable as the theoretical ground of this study.

The term "resources" refers to a variety of assets, capacities, practices, and traits, as well as information and expertise used to accomplish the objectives of an organization. Resources make it possible to establish and carry out initiatives (Barney, 1991; Barney et al., 2001; Bryson et al., 2007). Early research suggests that for these resources to truly impact the organization's performance, they must be Valuable, Rare, Unique, and Non-Replaceable (VRIN) (Wernerfelt, 1984). Particularly, VRIN resources enable businesses to create a competitive advantage, allowing better performance than their rivals over time. However, it is essential that the business not only has these resources but also has the organizational capacity to oversee them well. A company is said to have a "competitive advantage" if it has an approach to creating value that cannot be employed by its rivals in the present or in the future. A company is said to have a "sustained competitive advantage" when it maintains a superior market position that exhibits VRIN characteristics (Ahn et al., 2022). Accordingly, we aim to explore several capabilities of the metaverse and their impacts on the usage intention and the business's sustainable competitive advantage.

RBV also tries to clarify why businesses in the same industry have varying financial results. The RBV's guiding concepts can be distilled into two asserts in practice: the assets of a business that affect performance, and those assets that must be VRIN (Barney, 1991). The permanent maintenance of excellent performance depends critically on the strategic management of resources. For instance, if two companies are given access to VRIN resources, but only one of them utilizes them well, this company will have an edge over the other (Battisti et al., 2022). An organization can enhance effectiveness and maintain its competitive edge by properly combining and using locally held assets. In order to integrate and coordinate different kinds of assets, manufacturing skills, and innovation (i.e., core competence), it is necessary to develop a

competitive edge that can be sustained. This results in a shared learning environment that is specific to a given organization.

Based on the previous discussion, our objective is to investigate the influence of metaverse adoption on business performance, specifically in terms of sustainable competitive advantage. We will examine the assets it offers to businesses, such as infrastructure, spatial computing, and decentralized technology, and assess their impact on overall performance.

3. Literature Review on Metaverse

The concept of the metaverse entails several evolved concepts; as it has expanded from a limited single world to entail a more comprehensive view where multiple (virtual) realms are linked together (Dwivedi, Kshetri, Hughes, Rana, et al., 2023). It has also changed from being solely virtual to including a combined reality perspective (Koohang et al., 2023b) that includes Extended Reality (XR) experiences (i.e., Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) (Barrera & Shah, 2023). XR is a term used to describe a variety of immersive technologies that combine the physical and digital worlds (Doolani et al., 2020; Ratcliffe et al., 2021). These technologies enable an enhanced experience, incorporating sensory input from the real world along with digitally overlaid information. XR is a technology that includes VR (Huang et al., 2018), AR (Azuma, 1997), MR (Speicher et al., 2019), and other related technologies. VR technology creates a fully digital environment that can be interacted with other specialized equipment and allows for shaping future trends (Verma et al., 2022). Within this technology, users will be able to interact with objects and even communicate with other users in real-time while exploring and interacting with the virtual world. AR technology overlays digital information in the real world, improving the users' perceptions of their environment. MR technology combines the real and virtual worlds, which allows virtual objects to interact with real-world objects. This presents the users with a seamless and integrated experience, in which users can interact with virtual objects in a more natural and intuitive manner.

Spatial computing technology plays an important role in the metaverse by enabling and optimizing actions within XR systems (Delmerico et al., 2022). It involves the use of sensors, cameras, and other devices to capture and interpret data about the physical environment, and then the use of that data to create and manipulate digital content within XR environments. In the metaverse, users can create and customize their avatars and interact with other users in real-time. One of the key features of the metaverse is its potential for decentralized interactions (Murray et al., 2023). Instead of relying on centralized services, users can engage in direct transactions and interactions with other users, facilitated by decentralized protocols (e.g., blockchain technology) (H. Xu et al., 2022). The implementation of the blockchains in the metaverse enables decentralized storage of the data in blocks and the sharing of the data between the network nodes (Barrera & Shah, 2023).

Metaverse opens new opportunities for economic activity, in which users will be able to develop their virtual goods and services and build new applications and platforms using the metaverse capabilities. Retailers can interact with customers more immersively and interactively in the metaverse than traditional e-commerce websites or social media platforms (Yoo et al., 2023). Users in the metaverse will be able to interact with virtual representations of products, explore virtual stores, and even make real-time purchases. This level of immersion and interaction can help retailers build stronger connections with customers and increase brand awareness. One of the key advantages of the metaverse for retailers is the ability to provide a more personalized shopping experience. By leveraging data about customer preferences and behaviors, retailers in the metaverse can create customized shopping experiences that are tailored to each customer's

individual needs and interests. This can help to strengthen customer relationships with the company and increase customer loyalty. The ability of businesses to create engaging and memorable experiences that help differentiate their brand from competitors is another advantage of the metaverse for retailers. Retailers can retain customers by creating memorable, interactive, and fully immersive virtual environments and experiences.

The integration of Artificial Intelligence (AI) with other technologies in the metaverse has the potential to create a more scalable, secure, and realistic virtual world (Cheng et al., 2022; Y. Yang et al., 2022). AI plays a crucial role in ensuring the reliability of the infrastructure and improving its performance (Q. Yang et al., 2022). With the aid of AI, the metaverse can create a platform that is always on and can handle large volumes of data (Q. Yang et al., 2022). Human-machine interaction gadgets and wearable devices help AI-powered Deep Learning (DL) and Machine Learning (ML) models recognize and analyze a wide range of human movements and modalities, including emotions, facial expressions, body movements, and physical interactions. This allows users to naturally and intuitively control their avatars in the metaverse and interact with other objects. Furthermore, AI can be used to enable speech recognition and sentiment analysis. The potential for a complete engagement in virtual world interactions exists through the integration of AI with other metaverse technologies (Chang et al., 2022). AI's significant contribution to the metaverse is the creation of intelligent agents that can serve as virtual assistants, guides, or companions for users. These agents use natural language processing and machine learning to understand and respond to user input, creating personalized and engaging experiences. The use of AI in the metaverse has the potential to enhance the user experience and support business and product functions. AI in the metaverse has the ability to improve Natural Language Processing (NLP) (Ali et al., 2023), speech recognition (Siyaev & Jo, 2021), and computer vision (Hopkins, 2022). This will enable users to interact in the metaverse in their native language and get a better user experience. In fact, new technologies such as AI-powered chatbots (Xiao et al., 2020) can provide personalized and efficient customer service to users in the metaverse.

As an emerging area of research, the research in the metaverse has focused on the analysis of the challenges and opportunities of the metaverse adoption in several contexts of research such as the work by (Far et al., 2023; Marabelli & Newell, 2023; Shi et al., 2023), or proposing frameworks (Shi et al., 2023) or research agenda (Park & Lim, 2023; Yoo et al., 2023). Still, few researchers have focused on investigating the concepts of the metaverse using a user-based view; with more focus dedicated to retailing (Jafar et al., 2023), education (Akour et al., 2022), tokens usage (Albayati et al., 2023).

4. Model Development

This research aims to develop a new model for the adoption of the metaverse by retailing companies. The proposed relationships in the model are explained in this section and analyzed in the next section using the PLS-SEM approach.

- ***Perceived security and privacy→Attitude toward the metaverse (H1)***

As defined in the previous research, perceived security and privacy refer to an individual's subjective perception or belief about the level of security and privacy provided by a specific system, service, or technology (Yoon et al., 2020). It is frequently related to individuals' trust in a system or technology's ability to protect their personal information and maintain their privacy (Flavián & Guinalíu, 2006). Perceived security impacts an individual's level of trust in the security

measures (e.g., firewalls, encryption, access controls) provided by a particular technology (Sattarova Feruza & Kim, 2007). If a system is secure, people are more likely to use it for sensitive activities and share personal information with it. Perceived privacy, on the other hand, is the individuals' level of trust in a system or technology's ability to protect their personal information and prevent it from being disclosed or shared with unauthorized parties. Perceived security and privacy are important factors in technology adoption and use (Roca et al., 2009). In fact, if a system or technology seems secure and private, people are more likely to use it for sensitive tasks and share personal data with it. In addition, individuals are less likely to use a system or technology if they believe it is insecure or poses a privacy or security risk. Instead, they may seek out alternatives that they believe are more secure and protect their privacy.

Although the metaverse can enable social interaction, entertainment, and commerce, it may also perpetuate security and privacy risks. According to a survey conducted by J. Clement in 2022 (Statista, 2022e), metaverse followers in the United States have identified possible safety concerns about the metaverse, such as identity, data, device, and network cardinalities hacking, and the use of traditional or cryptocurrency payment methods in an unauthorized manner. According to the report, 71% of individuals polled were concerned about data privacy and security. In total, 43% of those polled were extremely frightened about having their identity stolen, while 34% were moderately concerned. 46% were not willing to give up their personal information or data in the metaverse any more than they would in a typical internet environment. Overall, 55% of those who were hesitant said they were unsure about how or who would manage their data. Privacy is a critical issue (Di Pietro & Cresci, 2021; Fernandez & Hui, 2022; Y. Wang et al., 2022) because the metaverse will collect vast amounts of personal data including biometric information, location data, and online behavioral data, which could be used for targeted advertising, identity theft, or other malicious purposes. Security is also a critical issue in the metaverse (Gupta et al., 2023; Y. Wang et al., 2022), as it has the potential to be vulnerable to cyber-attacks and other types of digital threats. To protect the integrity of the metaverse and prevent unauthorized access or manipulation of data, robust security protocols (e.g. encryption, authentication, and authorization) must be implemented to improve its adoption rate. Accordingly, building on the robust literature that investigated the impacts of perceived security and privacy on users' attitudes (Maqableh et al., 2021; Mombeuil & Uhde, 2021), the following hypothesis is proposed:

H1: Perceived security and privacy concerns negatively affect attitude toward the metaverse.

- ***Perceived complexity→attitude toward metaverse (H2)***

According to previous research (Gupta et al., 2013), the subjective perception or experience of a task, system, or technology's difficulty or complexity is referred to as perceived complexity (Gupta et al., 2013). It is a measure of the mental effort required to comprehend and use a system or technology. Complexity is a multidimensional concept that is influenced by a variety of factors such as the user's prior knowledge including skills and experience, and the design of the system. Hence, measuring technology complexity is not a straightforward task and there is no single method that can capture all aspects of technology complexity (Yadegaridehkordi et al., 2020). Therefore, it is important to use multiple methods and frameworks to measure and understand technology complexity in a comprehensive and nuanced way (Asadi et al., 2017).

The study by Tornatzky and Klein (1982) discovered a negative relationship between technology complexity and adoption. This indicates that the more complicated a technology is, the less likely

users are to adopt it (Yadegaridehkordi et al., 2020). The lack of required skills and knowledge is one of the key factors contributing to the perception of complexity in technology (Yadegaridehkordi et al., 2020). Users may perceive technology as complex and difficult to use if it requires a high level of technical expertise or specialized knowledge. In addition, users may be hesitant to invest time and effort in learning how to use the technology, which can be a major barrier to adoption. Furthermore, in the context of Business Information Systems (BIS), a lack of skills and knowledge required to effectively use innovations can be a significant barrier to the adoption. While many organizations are eager to adopt BIS to gain a competitive edge and improve their operations (Nguyen, 2009; Thong, 1999), the adoption may be slow or limited if employees lack the necessary knowledge and skills to use these systems and address the complexity barrier (Yadegaridehkordi et al., 2020).

The perceived complexity of technology can have a significant effect on the adoption and use of metaverse, especially in retail companies. Retail companies may be hesitant to adopt or use a system or technology if it is perceived as being too complex or difficult to use. In addition, retail companies are more likely to adopt and use the metaverse if it is perceived as simple to use and understandable. As a result, retail companies must invest in training and education programs to assist employees in developing the knowledge and skills required to effectively use the metaverse. This can help to reduce the perceived complexity of these systems and increase adoption rates. In this research, we build our hypothesis on the broad literature that has indicated the impact of the complexity on users' attitudes and intentions in diverse contexts such as m-wallet (Kaur et al., 2020), open data (Weerakkody et al., 2017), and green innovation (Kousar et al., 2017), and we propose:

H2: Perceived complexity negatively affects attitude toward the metaverse.

- ***Perceived cost → Attitude toward metaverse (H3)***

It is widely demonstrated that the perceived cost of a product, service, or technology can have a significant impact on an individual's attitude toward it (Asadi et al., 2017). The previous research shows that when the price of a product or service is excessive, it can have a negative impact on the customers' attitude toward it, even if they believe it is of high quality or value (Yadegaridehkordi et al., 2020). In contrast, when the price of a product or service is reasonable or low, the customers may have a favorable attitude toward it (Yadegaridehkordi et al., 2020). The relationship between perceived cost and attitude is frequently studied focusing on consumer behavior and purchasing decisions (Ma & Mei, 2019; Sun et al., 2022). When deciding whether to buy a product or service, consumers frequently weigh the perceived cost against the perceived benefits or value. In fact, consumers may decide not to make a purchase if the perceived cost is too high in comparison to the perceived benefits or value. It is important to note, however, that the relationship between perceived cost and attitude is not always clear. Personal preferences, social influence, and brand loyalty can all have an impact on an individual's attitude toward a product or service in relation to its cost.

The cost of developing and operating a metaverse can vary greatly depending on a variety of factors, including the metaverse's size, level of interactivity and complexity, and the technology infrastructure required to support it. Creating a metaverse usually necessitates a substantial investment in software development, hardware infrastructure, and content creation. According to Statista (2023a), metaverse market expansion may be hindered by the high cost of VR and AR

equipment and the absence of industry standards for manufacturing and distributing VR and AR content. To attract a critical mass of users to the platform, retail companies developing metaverses may need to invest in marketing and user acquisition strategies. Following the launch of a metaverse, ongoing costs may include content updates and maintenance, server and hosting costs, and ongoing software development and support costs. Companies may also need to invest in customer service and management to ensure a positive user experience and to deal with any issues that arise on the platform. Overall, the cost of creating and running a metaverse can be substantial, especially for larger and more complex platforms. Accordingly, the next hypothesis is presented referring to the broad literature that indicated the impact of the cost on customers' attitudes, attainments, and intentions (Li et al., 2019; Zuo et al., 2018):

H3: Perceived cost negatively affects attitude toward metaverse.

- ***Decentralized technology capabilities→Attitude toward the metaverse (H4)***

In centralized systems, decision-making and control are concentrated in a single authority, such as a government agency or a large corporation (King, 1983). Centralized technology has been effective in many technologies; however, it is associated with several potential drawbacks. One major concern is that centralized systems can be vulnerable to a single point of failure. Additionally, centralized technology can be associated with issues of transparency and accountability. With decision-making in a single authority, it can be difficult for outside parties to monitor or challenge the actions of the centralized authority. Accordingly, nowadays decentralized technology (Cai et al., 2018; Chen & Bellavitis, 2019) has been embedded into innovations. Decentralized technology refers to a class of technologies that rely on distributed networks and consensus algorithms to function, rather than centralized control structures (Cai et al., 2018; Chen & Bellavitis, 2019). In decentralized systems, decision-making is distributed across a network of nodes, rather than being concentrated in a single authority which can provide greater security and resilience than in centralized systems. Because decision-making is distributed across a network of nodes, there is no single point of failure that can compromise the entire system. Additionally, decentralized technology can provide greater transparency and accountability as transactions and decision-making are recorded on a distributed ledger, hence, it is more difficult for actors to engage in fraud or other nefarious activities without being detected. Decentralized technology is often associated with blockchain technology (Chen & Bellavitis, 2020; Pinna & Ibba, 2019), which uses a distributed ledger to record and verify transactions.

The use of decentralized technology is still relatively new and evolving, and there are challenges and limitations associated with its use. Decentralized technology capabilities have the potential to provide greater security, transparency, and accountability (Farnaghi & Mansourian, 2020). Decentralized technology is important in the development of metaverse platforms. Blockchain (Wan et al., 2023; Zheng et al., 2018), decentralized storage (Benisi et al., 2020), decentralized governance (Chen et al., 2021), and interoperability (Wegner, 1996) are some capabilities for decentralized technologies used in metaverse platforms. According to Statista (2023b), the growing demand for decentralized data management solutions is among the prominent factors that drive the development of virtual workplaces in the metaverse. Blockchain enables the creation and exchange of one-of-a-kind digital assets that can be purchased, sold, and traded in a decentralized fashion. By decentralized technologies, the metaverse platforms will be able to store user-generated content and assets using decentralized storage solutions. Interoperability between

different metaverse platforms can also be achieved through the use of decentralized technology (Mourtzis et al., 2022; Tang et al., 2022). Users would be able to seamlessly transfer assets and data between platforms, resulting in a more unified and connected metaverse ecosystem. The capabilities of the decentralized technology have gained researchers' interest recently and have been explored in different contexts (Guidi & Michienzi, 2021; Kuehner & Hartenstein, 2016), with less research that examined the topic referring to the metaverse adoption (A. Wang et al., 2022). Accordingly, the following hypothesis is proposed:

H4: Decentralized technology capabilities positively affect attitude toward the metaverse.

- ***Spatial computing capabilities→Attitude toward the metaverse (H5)***

Spatial computing is the use of technology to create interactive experiences that blend the physical and digital worlds (Shekhar et al., 2015). Spatial computing in virtual reality refers to the use of sensors and algorithms to track users' movements within a virtual environment (Delmerico et al., 2022), allowing them to interact with digital objects and navigate the virtual world as if they were physically present. The ability to create more immersive and realistic experiences is one of the primary advantages of spatial computing in VR (Bowman & McMahan, 2007). One way that spatial computing can be applied to online shopping is through the use of AR technology which enables users to view digital objects in the real world (Nuernberger et al., 2016). This will provide a more realistic sense of what a product would look like in its environment. VR can provide a fully immersive shopping experience that allows customers to explore a virtual store and interact with products in a more tactile way (Alzayat & Lee, 2021). In fact, personalized shopping experiences are created by spatial computing for customers. By collecting data about customer's preferences and behaviors, retailers can use spatial computing to tailor the shopping experience to customer's needs.

Spatial computing has had a significant impact on the evolution of the metaverse. Because the metaverse is an extension of virtual reality, spatial computing is critical in creating immersive and interactive experiences within it and the creation of realistic and interactive 3D environments (Majerová & Pera, 2022). Spatial computing capabilities enable unimaginable levels of interactivity and realism by allowing users to manipulate and interact with objects in real time (George et al., 2021). Spatial computing capabilities can help to create a sense of community and shared experience that is essential to the success of the metaverse by allowing users to interact with each other in real time and collaborate on projects and activities (Valaskova et al., 2022). According to the above discussion, we aim to explore users' perceptions of spatial computing capabilities and their impact on users' attitudes toward the metaverse. This construct has been explored in the literature focusing on the development-centric fold (Yan & Rhodes, 2008), with less attention to users' perceptions and evaluation. Hence, we present the next hypothesis:

H5: Spatial computing capabilities positively affect attitude toward the metaverse.

- ***Infrastructure → attitude toward metaverse (H6)***

Metaverse development is complex with several key components required to make it a reality (Cai et al., 2022; M. Xu et al., 2022). High-speed internet and data connectivity are critical components of the metaverse. In the metaverse, massive amounts of data transfer are required to create seamless, immersive experiences that can handle large numbers of users interacting in a real-time manner. This necessitates the use of a high-bandwidth network infrastructure that is capable of

handling the demands of real-time interaction and data transfer. Hardware is another important component of the metaverse. The current internet infrastructure may not be sufficient to support the creation of a fully immersive content-streaming metaverse environment. The metaverse necessitates a high-bandwidth network infrastructure that is capable of handling the demands of real-time interaction and data transfer, which is currently not widely available. To bring the metaverse vision to life, it is necessary to make significant investments in hardware and foster the convergence of technology. The hardware required to access and interact with the metaverse will become more immersive and sophisticated as it grows more immersive and sophisticated (Park & Kim, 2022). Network infrastructure advancements (Tang et al., 2022) (e.g., 5G and 6G) in the metaverse can support massive amounts of data transfer and real-time interactions. Accordingly, to support massive amounts of data transfer and real-time interactions between users, the metaverse necessitates specialized server infrastructure (Mystakidis, 2022).

The development of the metaverse will also rely heavily on software infrastructure (Y. Wang et al., 2022). To support the creation, distribution, and management of virtual content across multiple platforms, sophisticated tools need to be developed. This includes technologies such as haptic feedback systems, which can simulate touch and eye-tracking systems and enable more natural interaction with virtual environments. Overall, significant investment in the convergence of technology is required to make the metaverse vision a reality. This includes improvements to software infrastructure, hardware, network infrastructure, and specialized server infrastructure to support the metaverse's massive amounts of data transfer and real-time interactions. Although the infrastructure's importance has been explored in the literature in other contexts, such as e-government diffusion (Ngafeeson & Merhi, 2015) and economic performance (Yeo et al., 2020), to the best of our knowledge, it has not been explored focusing on user's evaluation of the metaverse. Accordingly, the following hypothesis is proposed:

H6: Infrastructure positively affects attitude toward metaverse.

- ***Sustainability awareness→Sustainability commitment (H7)***

As with the physical world, sustainability awareness (Herremans & Reid, 2002; Oriade et al., 2021) in the metaverse is important for ensuring that digital activities do not have negative impacts on the society and environment. Sustainability awareness refers to an individual's level of understanding and knowledge of the environmental, social, and economic impacts of their actions and decisions (Mojilis, 2019; Strada et al., 2023). It involves recognizing the interconnectedness of various systems and the need for a balance between the potential impacts and human activities. Sustainability commitment, on the other hand, refers to an individual's level of dedication and action toward sustainable practices. It involves making conscious choices to reduce one's impact on the environment and promote economic equity and social.

From the previous studies, it is found that there is a strong relationship between sustainability awareness and sustainability commitment (Abramovich & Loria, 2015; Barr, 2007). A higher level of sustainability awareness tends to lead to a greater commitment to sustainable practices. When individuals understand the impact of their actions, they are more likely to take steps to reduce their negative impacts on the environment, economy, and society. Additionally, sustainability awareness can help individuals identify areas where they can make changes to their behavior and lifestyle to align with sustainable practices. It can also help individuals recognize the importance of sustainability and prioritize it in their decision-making.

Extending these assumptions to the context of metaverse adoption, we hypothesize that promoting sustainability awareness in the metaverse is important for ensuring that digital activities align with sustainable practices and do not have negative impacts on the environment, economy, and society. Referring to (METAV.RS, 2023), by implementing green technology, fostering digital literacy, and supporting the use of Non-Fungible Tokens (NFTs) and blockchain, which are more transparent and secure ways to manage information and operations, the metaverse can accomplish sustainability. Sustainability in the metaverse involves incorporating sustainable practices into virtual design and development, education, and community involvement and participation. Overall, sustainability awareness and commitment are interconnected (Khalil & Khalil, 2022; Strada et al., 2023), with awareness often leading to a greater commitment to sustainability practices. Accordingly, the following hypothesis is proposed:

H7: Sustainability awareness positively affects sustainability commitment.

- ***Sustainability commitment → Attitude toward metaverse → Intention to use metaverse (H8)***

In comparison to hosting online infrastructure like an Apache web server, the metaverse produces a substantially higher carbon footprint and uses a great amount of energy (Green Revolution Cooling, 2022). Due to the integration of AR, VR, AI, blockchain, cloud computing, and other cutting-edge technologies, running the metaverse demands a significant amount of computing and processing power and may result in substantial carbon dioxide (CO2) emissions (Green Revolution Cooling, 2022). Due to the need for new hardware products and the tendency toward quick model obsolescence, one environmental concern related to the metaverse is the production of substantial amounts of e-waste (Kshetri & Dwivedi, 2023). Another argument toward metaverse use is built on the perception that the ability to work, communicate, shop, and learn online allows for a reduction in physical activities, which would cut energy use (Bianzino, 2022). According to Kshetri and Dwivedi (2023), it is crucial to take into account both the existing and potential uses of this innovation since the pollution-generating and pollution-reducing effects of the metaverse vary dramatically across various activities. All these issues raise the need for a level of commitment toward sustainability issues among all parties involved in the development and implementation of the metaverse.

Sustainability commitment has been an important factor in technology adoption. It refers to an individual's or organization's dedication to adopting and promoting sustainable practices and behaviors (Chen & Chen, 2019). This commitment can take many forms, such as implementing sustainable policies and practices in daily operations (Chen & Chen, 2019), using sustainable products and services, or actively advocating for sustainable initiatives (Dzomonda & Fatoki, 2020). Sustainability commitment can stem from various motivations, including ethical and moral values, a desire to reduce environmental impact, or a recognition of the economic benefits of sustainable practices (Chen & Chen, 2019; Dzomonda & Fatoki, 2020). Individuals and organizations with high levels of sustainability commitment are likely to prioritize sustainability in their decision-making processes and take actions to reduce their environmental impact. Sustainability commitment is important for promoting sustainable development and addressing global challenges such as climate change and resource depletion. It can also lead to improved environmental and social outcomes, such as reduced waste, improved energy efficiency, and increased social equity.

Sustainability commitment can play a moderating role in the relationship between attitude and intention to use sustainable products or services. Attitude refers to an individual's positive or negative evaluation of a particular product or service, while intention to use refers to an individual's likelihood of using or adopting a product or service. When individuals have a high level of sustainability commitment, they are more likely to act in accordance with their positive attitudes towards sustainable products or services. In other words, their commitment to sustainability can strengthen the relationship between their positive attitudes and their intention to use sustainable products or services. On the other hand, when individuals have a low level of sustainability commitment, their positive attitudes towards sustainable products or services may not necessarily translate into an intention to use them. In this case, their attitude to sustainability may not be strong enough to overcome other factors that may be considered barriers to using sustainable products or services. Therefore, sustainability commitment can act as a moderator of the relationship between attitude and intention to use sustainable products or services. This highlights the importance of promoting sustainability commitment in addition to positive attitudes towards sustainability to encourage the adoption and use of sustainable products or services. Commitment imposed moderation impacts in the context of e-payment technology on the relationships between three factors (ease of use, usefulness, and social image) and the intention to use in the study by Oloveze et al. (2022). Accordingly, the following hypothesis is proposed:

H8: Sustainability commitment positively moderates the relationship between attitude toward metaverse and intention to use metaverse.

- ***Attitude toward the metaverse→Intention to use the metaverse (H9)***

Attitude toward technology can strongly influence an individual's intention to use it (Vijayasarathy, 2004). Attitude refers to a person's overall evaluation or feeling about a particular object or concept (van Aalderen-Smeets et al., 2012). Intention to use, on the other hand, refers to a person's plan or willingness to use the technology in the future (Jeyaraj *et al*., 2023; Luarn & Lin, 2005). Research in the field of technology acceptance has consistently shown that attitude is a strong predictor of intention to use (Habibi et al., 2022; Vijayasarathy, 2004). If a person has a positive attitude toward technology, they are more likely to have a strong intention to use it (Pierce & Ball, 2009). In contrast, if a person has a negative attitude toward technology, they are less likely to intend to use it. Several factors influence the relationship between attitude and intent to use. For example, individuals' perceptions of the technology's usefulness, cost, and complexity in relation to their needs and values can all influence their attitudes toward it. Overall, a positive attitude toward the metaverse is likely to increase an individual's intention to use it, whereas a negative attitude is likely to decrease the intention to use it. Although the relationship between the attitude and the intention to use has been robustly proved in the literature (Ahmmadi et al., 2021; Xu et al., 2020), in the context of the metaverse adoption it has been rarely explored in the literature. As a result, the following hypothesis is proposed:

H9: Attitude toward the metaverse positively affects intention to use the metaverse.

- ***Intention to use the metaverse→Product innovation (H10)***

Technology plays a crucial role in driving product innovation (Cooper, 2000). Advances in technology can enable businesses to create new and innovative products that were previously not possible (Vásquez-Urriago et al., 2014). Technology can also help businesses to optimize existing products and services, making them more efficient and effective (Awazu et al., 2009). To create new products and services, the role of new technologies in companies is significant. The rise of innovations such as virtual and augmented reality technologies has enabled businesses to create immersive and interactive experiences that were previously not possible. This has opened up new opportunities for businesses to create innovative products that provide users with more engaging and exciting experiences. XR technologies are being increasingly used in product innovation (El-Jarn & Southern, 2020), allowing companies to create new and innovative products that are more engaging, immersive, and interactive. Additionally, the use of XR technologies has been effective in product education and training (Doolani et al., 2020). With XR technologies, companies can use VR simulations to train employees on how to use new products or equipment in a safe and controlled environment. This not only improves employees' performance but also reduces the risk of accidents and injuries.

By using AR applications, consumers can visualize products in their real-world environment, allowing them to see how products would look in their homes or workplaces before making a purchase (Qin et al., 2021). This enhances the shopping experience and can increase customer satisfaction and loyalty (Jeon, 2023). Accordingly, many businesses are exploring ways to leverage metaverse for product innovation (Hazan et al., 2022; Sayem, 2022).

When users are motivated to use the metaverse, they are more likely to be open to new and innovative products that are developed for this platform. As a result, retail companies can use the metaverse to develop and launch novel products that would not be possible in traditional settings. Furthermore, with the use of the metaverse, retail companies will be able to collect real-time feedback from customers. This feedback can be used to inform the development of new products and services that meet the evolving needs of users. Retail companies can reduce the risk of launching products that do not resonate with their target audience by leveraging the metaverse to test and refine new products. By developing innovative products that are specifically designed for the metaverse, retail companies can differentiate themselves from their competitors and capture a larger share of the market. As such, the intention to use the metaverse may have a positive impact on product innovation. Retailers will be able to develop and launch innovative products that meet the changing needs of their users by leveraging the metaverse's unique features. Although previous literature has explored the product innovation construct as an enabler of different outcomes such as branding and customer attraction (Yoshioka-Kobayashi et al., 2020), attitude toward purchase intention of innovative products (Seng & Ping, 2016), and stakeholder involvement with innovativeness (von der Heidt & Scott, 2009); the factors that might impact the product innovation has not been explored in the literature broadly. Accordingly, the following hypothesis is proposed:

H10: Intention to use the metaverse positively affects product innovation.

- ***Product innovation→Sustainable competitive advantage (H11)***

Sustainable competitive advantage refers to a company's ability to maintain a competitive edge over its rivals in the long term (Coyne, 1986). This competitive advantage can come from a variety of sources, including the company's unique products or services, brand reputation, operational efficiency, or intellectual property. A company's long-term success requires a sustainable

competitive advantage because it allows it to generate superior profits while maintaining market share (Srivastava et al., 2013). A company can differentiate itself and create a unique value for customers by developing more innovative products, with higher quality, or more cost-effective than those of its competitors. Increased customer loyalty, market share, and profitability can all contribute to a long-term competitive advantage (Angelmar, 1990; Kuncoro & Suriani, 2018). Product innovation can be a key driver of companies' performance and sustainable competitive advantage (Vladimirov, 2016). Moreover, product innovation can also help companies respond to changing market conditions and emerging trends (Angelmar, 1990; Dai et al., 2020; Kuncoro & Suriani, 2018). However, in order for product innovation to contribute to sustainable competitive advantage, it must be sustained over time. This requires a commitment to ongoing research and development, as well as a culture of innovation that values experimentation, risk-taking, and continuous improvement. Furthermore, product innovation must be aligned with the broader strategic goals of the company. For example, if a company's strategy is focused on sustainability, then product innovation must also prioritize environmental and social considerations. This can involve using eco-friendly materials, reducing waste, or designing products that promote healthier lifestyles.

Product innovation by metaverse can potentially lead to sustainable competitive advantage for businesses. In terms of sustainable competitive advantage, product innovation by metaverse can help companies differentiate themselves from competitors and create a unique value proposition. By offering innovative products that meet customer needs and preferences in a unique and engaging way, retailers will be able to build a strong brand reputation and customer loyalty. This can create barriers to entry for new competitors and reduce the threat of substitute products. We extend previous literature that investigated the product innovation factor, as an enabler of the brand prototype (Yi et al., 2022) and as a driver of the attitude toward purchase intention of innovative products (Seng & Ping, 2016) by examing the impact of product innovation on sustainable competitive advantage. Accordingly, the following hypothesis is proposed:

H11: Product innovation positively affects sustainable competitive advantage.

According to the above hypotheses, the proposed model is shown in Fig. 1. In this model, 11 hypotheses are included, in which sustainability commitment acts as a moderator for the relationship between attitude toward the metaverse and intention to use the metaverse. In the model, we examined the impacts of three factors related to individuals' perceptions of metaverse usage (perceived privacy and security concerns, perceived complexity, and perceived costs) and the impacts of three technology-based factors (decentralized technology capabilities, spatial computing capabilities, and infrastructure) on the attitude toward the metaverse usage. The model is evaluated in the next section using PLS-SEM.

5. Data Collection and Data Analysis

5.1 Data Collection

We used an electronic-based questionnaire collected from 420 retail companies (small, micro, and medium) in Malaysia based on the type of products and/or services their business produces/provides to evaluate the proposed model. To reach out to these companies, we utilized their email addresses as a means of communication. Each company received an email containing the survey questionnaire, inviting them to participate in the study. We made a concerted effort to ensure that the email invitations were sent to a wide range of retail companies, reflecting the

diverse nature of the retail sector in Malaysia. After one week of the first email, we sent a reminder email encouraging them to participate in the study. Eventually, we had a usable and valid sample of 405 responses, which is considered adequate for examining the factors of the proposed model. In this study, our target population consists of employees holding different positions within the retail industry in Malaysia. We deliberately targeted this group in order to acquire knowledge of the practical perspectives of the employees in the retail industry. The survey entailed two main parts of demographic data and the evaluation of the measurement items. The analysis of the demographic data is presented in Table 1. The majority of the respondents were males with a percentage of 76.79%. The age intervals for the respondents are primarily fallen in the intervals of 30–35, 36–40, 41–45, and 46–50; with ratios of 18.77%, 28.4%, 21.98%, and 22.22%, respectively. In terms of the type of products and/or services provided; diverse types were chosen by the respondents; including "Beauty & Lifestyle", "Business Support & Supplies", "Cars & Automotive", "Computers & Electronics", "Construction & Engineering, Education", "Entertainment", "Fashions & Accessories", "Food & Dining", "Healthcare & Medication", "Home & Living", "Logistics & Transportation", "Services", "Sports & Hobbies", "Trading & Manufacturing", and "Travel & Leisure". In terms of company size, the majority of the respondents indicated that their companies are small-sized companies (<5 employees), with a percentage of 56.79%. The majority of the respondents have 3 to 4 years of experience in retailing. Finally, most of the respondents indicated that they are moderately familiar with the metaverse (50.37%).

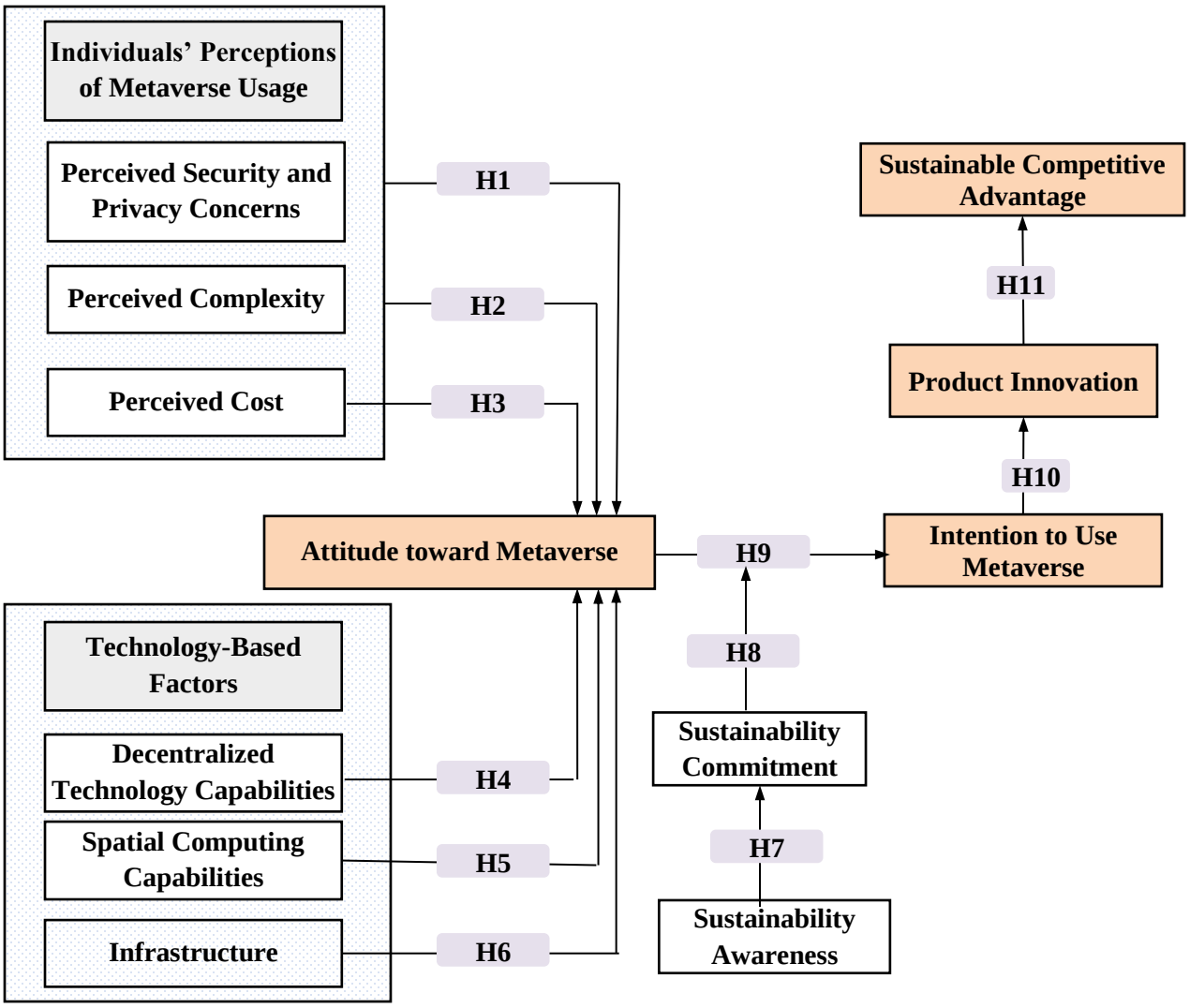

Fig. 1. Research model

5.2 Data analysis

The PLS-SEM guidelines were used in this research to evaluate the validity and reliability of the measurement items and to scrutinize the significance of the relationships (Hair Jr et al., 2020). In order to theoretically evaluate a research model that contains a set of constructs, researchers usually employ an SEM technique. SEM enables the researcher to estimate and evaluate the proposed connections between the constructs of the structural model (Nilashi, Baabdullah, et al., 2023). Constructs could be estimated by an observable collection of indicators, while these constructs are not directly observable (Guenther et al., 2023). Among SEM approaches, Partial Least Square-Structural Equation Modelling (PLS-SEM) has gained researchers' interest in the field of information system research (Hair et al., 2013). According to Kante and Michel (2023), researchers use PLS-SEM for several reasons, including its capability to handle small sample sizes, nonnormal data, complex models, and its efficiency in estimating the parameters.

The measurement items are shown in Table 1 of Appendix A. The measurement model's reliability and validity were assessed using the instructions established by Hair Jr et al. (2020), who proposed that we test internal consistency reliability, convergent validity, and discriminant validity. After

the initial assessment of the data and to meet the reliability and validity tests, we deleted PIN3, as suggested by Hair et al. (2013). Cronbach's Alpha values fall in the range of 0.740 to 0.914 as presented in Table 2. The composite reliability values also exceeded the threshold of 0.7, indicating that measurement items have satisfactory internal consistency (Hair Jr et al., 2020). For assessing convergent validity in PLS-SEM, the Average Variance Extracted (AVE) and outer loadings tests were recommended. Hair Jr et al. (2020) proposed that AVE is satisfactory if the values for all constructs exceed 0.5, and the outer loading is acceptable if the value is 0.7 or higher. The AVE value's range for the constructs was from 0.657 to 0.904, as shown in Table 2, and all outer loading values range from 0.737 to 0.953. Hence, the obtained results imply adequate convergent validity.

Table 1. Demographic results of the participants (N=405)

Feature	Item	Frequency	Percentage
Gender	Female	94	23.21
	Male	311	76.79
Age	Under 30	12	2.96
	30 – 35	76	18.77
	36 – 40	115	28.4
	41 – 45	89	21.98
	46 –50	90	22.22
	51 and over	23	5.68
Type of products and/or services does your company mainly produce/provide	Beauty & Lifestyle	49	12.1
	Business Support & Supplies	10	2.47
	Cars & Automotive	38	9.38
	Computers & Electronics	11	2.72
	Construction & Engineering	22	5.43
	Education	7	1.73
	Entertainment	35	8.64
	Fashions & Accessories	31	7.65
	Food & Dining	38	9.38
	Healthcare & Medication	32	7.9
	Home & Living	14	3.46
	Logistics & Transportation	5	1.23
	Services	48	11.85
	Sports & Hobbies	13	3.21
	Trading & Manufacturing	14	3.46
	Travel & Leisure	21	5.19
	Other	17	4.2
Size of the company	Small (<5 employees)	230	56.79
	Micro (5-75 employees)	167	41.23
	Medium (76-199 employees)	8	1.98
Experience in retailing	Less than 1 year	27	6.67
	1 to 2 years	10	2.47
	3 to 4 years	191	47.16
	5 years or more	177	43.7
Level of familiarity with the metaverse	High Familiarity	60	14.81
	Moderate Familiarity	204	50.37
	Low Familiarity	141	34.81

Table 2. Obtained results for measurement models

Item	Outer loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Attitude toward Metaverse				
AM1	0.928			
AM2	0.930			
AM3	0.912	0.914	0.945	0.853
Decentralized Technology Capabilities				
DET1	0.914			
DET2	0.922	0.813	0.915	0.843
Intention to_Use Metaverse				
IM1	0.856			
IM2	0.850			
IM3	0.835	0.803	0.884	0.717
Infrastructure				
INS1	0.953			
INS2	0.948	0.894	0.949	0.904
Perceived Complexity				
PC1	0.884			
PC2	0.878			
PC3	0.874	0.852	0.91	0.772
Perceived Cost				
PCS1	0.932			
PCS2	0.916	0.830	0.921	0.854
Product Innovation				
PIN1	0.923			
PIN2	0.923	0.827	0.92	0.852
Perceived Security & Privacy				
PSPC1	0.885			
PSPC2	0.905			
PSPC3	0.864	0.862	0.915	0.783
Sustainability Awareness				
SUSA1	0.893			
SUSA2	0.930			
SUSA3	0.877	0.883	0.928	0.811
Sustainable Competitive Advantage				
SCA1	0.841			
SCA2	0.848			
SCA3	0.737	0.740	0.851	0.657
Spatial Computing Capabilities				
SPC1	0.860			
SPC2	0.849			
SPC3	0.885	0.834	0.899	0.748
Sustainability _Commitment				
SUSC1	0.823			
SUSC2	0.804			
SUSC3	0.856	0.772	0.867	0.686

Heterotrait-monotrait ratio (HTMT) test was implemented for assessing discriminant validity in the PLS-SEM, as presented in Table 3. HTMT is the mean of all correlations of indicators across constructs measuring various concepts (Hair et al., 2013). Lower HTMT ratios indicate greater discriminant validity, suggesting that the constructs are distinct rather than highly connected, which has been achieved in this research.

Table 3. Heterotrait-Monotrait Ratio (HTMT) Criterion

	AM	**DET**	**INS**	**IM**	**PCS**	**PSPC**	**PC**	**PIN**	**SPC**	**SUSA**	**SUSC**	**SCA**
AM												
DET	0.629											
INS	0.643	0.635										
IM	0.76	0.767	0.76									
PCS	0.613	0.69	0.674	0.7								
PSPC	0.653	0.698	0.697	0.701	0.661							
PC	0.742	0.684	0.701	0.788	0.833	0.684						
PIN	0.618	0.615	0.56	0.571	0.671	0.898	0.651					
SPC	0.649	0.716	0.616	0.801	0.707	0.745	0.692	0.674				
SUSA	0.604	0.649	0.896	0.725	0.618	0.713	0.715	0.618	0.637			
SUSC	0.439	0.5	0.632	0.566	0.485	0.627	0.478	0.693	0.514	0.665		
SCA	0.511	0.465	0.466	0.421	0.531	0.63	0.531	0.793	0.55	0.571	0.628	

Because the results of the measurement model analysis in the previous section were satisfactory, the next stage in PLS-SEM analysis is structural model evaluation. According to Hair Jr et al. (2020), some criteria for evaluating the relationships include the coefficient of determination (R^2) and the significance of the path coefficient. Fig. 2 and Table 4 show the results of the structural model assessment. However, before testing the structural model, Hair Jr et al. (2020) recommended assessing the collinearity issue with VIF to ensure that it did not bias the regression outcomes. As per Hair Jr et al. (2020), if the acquired VIF score is higher than five, the construct is collinear. The VIF results show that all constructs have values below the predefined level. Table 4 displays the hypotheses test results by calculating the path coefficient, p-value, and t-value with 5000 resamples by using a bootstrapping procedure. The analysis of the inner model is visualized in Fig. 2. Most research hypotheses were accepted except for H3 and H4. Hence, the perceived cost does not imply an impact on the attitude toward the metaverse. Besides, decentralized technology capabilities do not impose an influence on the attitude towards the metaverse. On the other hand, the moderation impact was also rejected. Hence, there is no moderation influence of the sustainability commitment on the relationship between attitude toward the metaverse and the

intention to use the metaverse. However, the analysis result supports a new relationship between sustainability commitment and the intention to use metaverse.

Lastly, we consider the impact sizes of the links between the factors to assess their practical importance referring to the effect size test. The effect size is an indicator of an effect's intensity that is unaffected by sample size. The f^2 values that range from 0.020 to 0.150, 0.150 to 0.350, or equal or greater than 0.350, indicate small, medium, or large effect sizes, respectively (Cohen, 1988). Still, referring to Benitez et al. (2020), the majority of constructs rarely, if ever, have a substantial effect size in the model. We make this distinction because researchers frequently require or anticipate that all or the majority of their effects have big magnitudes, which is a wildly exaggerated expectation. The f^2 values for the majority of the proposed links in our model range from 0.024 to 0.646 (small to large).

Finally, we present the coefficients of the determination test. This test uses an endogenous construct's percentage of variance, which can be proven using the exogenous variables. For endogenous constructs, the R^2 values range from 0 to 1, with larger values suggesting more prediction accuracy (Hair Jr et al., 2020). As a general rule of thumb, endogenous latent variables with R^2 values of 0.75, 0.50, or 0.25 can be categorized as considerable, moderate, or weak (Hair Jr et al., 2020). Table 5 displays the outcomes of the coefficients of the determination test. R^2 values, as we can see, range from 0.217 to 0.533.

Table 4. Structural Model Assessment

Hypothesis	Path	Path coefficient	T-value	P-value	VIF	F^2	Status
H1	Perceived Security & Privacy Concerns -> Attitude toward Metaverse	-0.137	2.445	0.015	2.206	0.029	*
H2	Perceived Complexity -> Attitude toward Metaverse	-0.348	4.653	0.000	2.447	0.106	**
H3	Perceived Cost -> Attitude toward Metaverse	-0.030	0.401	0.689	2.328	0.001	NS
H4	Decentralized Technology Capabilities -> Attitude toward Metaverse	0.100	1.806	0.071	1.939	0.011	NS
H5	Spatial Computing Capabilities -> Attitude toward Metaverse	0.154	2.419	0.016	2.141	0.024	*
H6	Infrastructure -> Attitude toward Metaverse	0.166	2.524	0.012	2.014	0.029	*
H7	Sustainability Awareness -> Sustainability Commitment	0.554	13.054	0.000	1.000	0.444	**
H8	Sustainability Commitment x Attitude toward Metaverse -> Intention to Use Metaverse	0.004	0.102	0.918	1.079	0.000	NS
H9	Attitude toward Metaverse -> Intention to Use Metaverse	0.564	13.409	0.000	1.245	0.489	**
H10	Intention to Use Metaverse -> Product Innovation	0.466	9.082	0.000	1.000	0.277	**
H11	Product Innovation -> Sustainable Competitive Advantage	0.627	17.030	0.000	1.000	0.646	**
Additional	Sustainability Commitment -> Intention to Use Metaverse	0.242	5.419	0.000	1.162	0.097	**
Significant at P** < 0.01, P*< 0.05 and Not Significant (NS) at P>=0.05							

Table 5. R-Square Test

Output Variables	**R-square**	**R-square adjusted**
Attitude toward Metaverse	0.533	0.526
Intention to Use Metaverse	0.478	0.474
Product Innovation	0.217	0.215
Sustainability Commitment	0.307	0.306
Sustainable Competitive Advantage	0.393	0.391

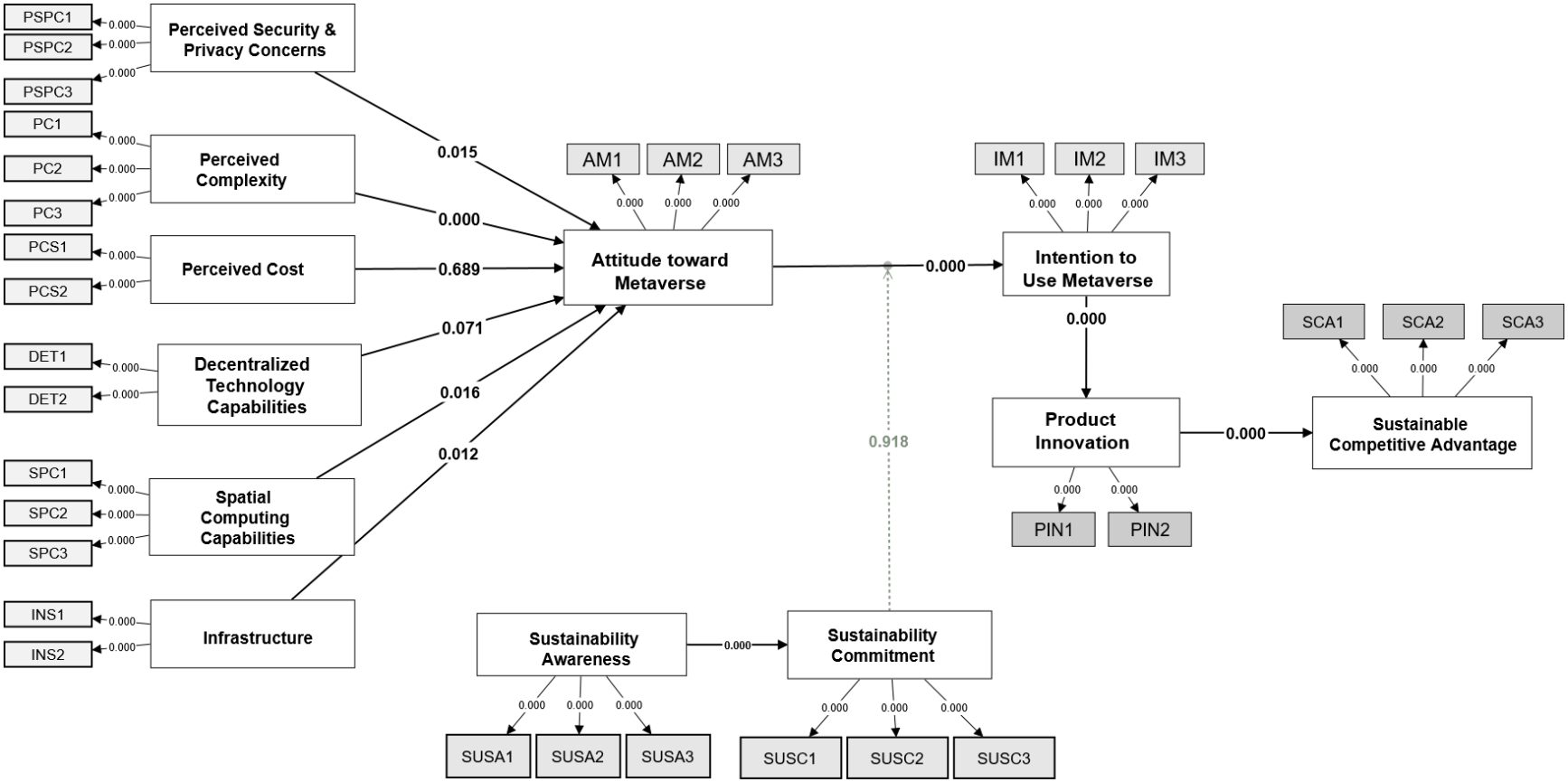

Fig. 1. Structural path analysis results

6. Discussion

The results of the analysis presented several outcomes, which we will discuss in this section in detail. The research outcomes supported the first hypothesis; hence, perceived security and perceived privacy have significant impacts on the attitude toward the metaverse. Previous literature has explored security and privacy concerns within the realm of virtual reality. However, researchers have merely concentrated on the technical aspects related to security and privacy, such as the work by Odeleye et al. (2023), which provides a taxonomic representation of the potential security challenges. On the other hand, insufficient attention has been given to the users' perceptions of the security and privacy risks associated with the adoption of the metaverse, except for the results obtained from online surveys such as Statista (2022e). Since the metaverse will collect a lot of personal data, the privacy factor is important for retailers. In addition, the metaverse may be vulnerable to security threats; hence, it is necessary to employ strong security measures, such as encryption, authentication, and authorization.

The second hypothesis; which indicates that perceived complexity impacts the attitudes toward the metaverse, was also supported. The endorsement of this hypothesis runs smoothly with previous literature in related contexts such as the work by Akour et al. (2022), which examined the adoption intention of the metaverse in the context of higher education. The adoption and use of technology, including the metaverse, can be significantly impacted by how complex it is perceived. The perceived complexity of a system or technology may deter organizations from implementing it. A user-friendly metaverse, on the other hand, is more likely to be adopted by retail enterprises.

The third hypothesis was rejected, indicating that the perceived cost does not impact the attitude toward the metaverse. This runs with the result from Salim et al. (2022), which indicated the insignificant impact of the perceived cost on the intention to adopt blockchain technology. The authors attributed this to the fact that blockchain technology is still in its infancy and that there is currently no reliable method for calculating the monetary expense of adopting the system or its expected expense-benefit ratio, which we believe runs smoothly within the context of this study. Besides, consumers commonly compare the perceived cost of a good or service to its benefits or value when determining whether to purchase or adopt it. If the perceived cost is excessively high in relation to the perceived benefits or value, consumers could decide against buying the product. On the other hand, if the technology can provide significant productivity gains, users might be willing to overlook the perceived cost. Still, the link between attitude and perceived expense is not always clear. Several factors, such as financial circumstances, cultural background, and other contextual factors; have an impact on an individual's attitude toward the cost of a product or service.

The fourth hypothesis was also rejected; indicating that decentralized technology does not impact the attitude towards the metaverse. Although blockchain technology and other decentralized protocols enable users to conduct direct transactions and interactions with other users rather than depending on centralized platforms or services; in this research, the retailers perceived the decentralization concept as an insignificant factor, which impacted their attitudes toward the metaverse. This can be explained by the perception of difficulty in the coordination process in decentralized systems. Making decisions might be challenging because there are so many people to consider.

The research also indicated that spatial computing capabilities have a significant impact on attitudes toward the metaverse. Although several studies have explored spatial computing capabilities, they have merely focused on algorithm-centric development and evaluation (Werner, 2019), with relatively less attention given to exploring users' perceptions of this aspect. Hence, our

study presents a novel outcome as it explores the users' perceptions of spatial computing capabilities in the context of metaverse adoption. It is anticipated that actions in XR systems are made possible and can be optimized by spatial computing technology, entailing the use of sensors, cameras, and other devices to gather and interpret data about the actual environment. Spatial computing capabilities allow users to manipulate and interact with things in real time, which can impact the adoption of the metaverse by improving immersion, increasing accessibility, enhancing realism, and facilitating greater interoperability.

The results of the research support the impact of the infrastructure on the attitude toward the metaverse. While previous studies have focused primarily on the technical aspects of research related to the metaverse, there is a lack of exploration regarding users' perceptions of the infrastructure capabilities and other factors associated with the technology itself. The metaverse needs a sophisticated infrastructure that can enable the production, delivery, and administration of virtual content across several platforms and devices. Hence, it will be necessary to create gaming engines, development tools, and content management systems to support that.

Hypothesis 7 was supported by the results; indicating that sustainability awareness impacts sustainability commitment. The desire for more contemporary and sustainable systems has increased among corporations worldwide since the UN 2030 SDGs were announced in 2015 (Nilashi, Abumalloh, et al., 2023). The result of the study supports previous literature in other contexts such as the work by Safari et al. (2018). According to the authors, environmental knowledge and awareness will enhance employees' commitment to environmentally friendly practices and behavior inside the company. Similar findings were reported by Chan et al. (2014), in which environmental knowledge and awareness imposed high impacts on the employees' ecological behaviors. It is critical to emphasize the current movement in business management from a system-based approach oriented purely on customers to a more holistic strategy that aligns both sustainability and customer-centricity which is driven by the increasing levels of knowledge and consciousness (Hallioui et al., 2022). A stronger commitment to sustainable activities typically results from increased sustainability awareness. People are more inclined to take action to lessen their harmful effects on the environment and society when they are aware of the consequences of their behaviors. Furthermore, individuals' awareness of sustainability can assist in identifying areas where they might modify their lifestyle and behavior to be more in line with environmentally friendly habits. Additionally, it can assist people in prioritizing sustainability in their decision-making and recognizing its significance. It is crucial to raise awareness of sustainability in the metaverse so that digital activities adhere to sustainable principles and don't harm society or the environment. An additional relationship was supported by the analysis indicating that sustainability commitment impacts the intention to use the metaverse. As more people become environmentally conscious, they become more inclined to use virtual environments that prioritize sustainability. A commitment to sustainability can attract users who are concerned about the impact of their digital activities on the environment, and this can lead to increased adoption of sustainable metaverse platforms. Sustainability commitment can help metaverse platforms build a positive brand image and reputation, which can attract users who value sustainability.

The research indicates the impact of the intention to use the metaverse on product innovation and the impact of the product innovation on the sustainable competitive advantage. In the study by Majali et al. (2022), the authors indicated the significant impact of product innovation on the performance of SMEs. Besides, in the context of transition economies, product innovation imposed a significant impact on the firm's performance in the study by Ramadani et al. (2019). The

metaverse can give companies a sustainable competitive advantage over their rivals and get a bigger market share by creating cutting-edge items that are especially suited for the metaverse and can address the evolving demands of their users.

7. Research Implications

The purpose of this study was to investigate the degree to which retail companies are willing to adopt the metaverse as a new technology. There are several research implications from our findings which are summarized as follows:

7.1. Theoretical Contribution

i. Using RBV theory, this study developed a new model of the adoption of the metaverse. This study proposed several hypotheses to investigate the relationship between attitude and intention to use the metaverse in retail companies. This theory was applied to the metaverse's adoption by investigating the unique resources and capabilities that retail companies can use to gain a competitive advantage in this new environment. The research's hypotheses provided insights into the elements that influence the adoption in this setting by examining the relationship between favorable perceptions about the metaverse capabilities and the intention to employ it in retail businesses. According to RBV theory, the essence of competition is the growth of an organization's distinctive resources rather than just reacting to developments in the external surroundings. As a result, innovation allows businesses to create unique assets to boost the organization's performance and achieve sustainability while building constraints that others find difficult to challenge. We discovered that an appropriate integration of digital resources can help enterprises obtain a competitive edge in the digital world. Particularly, we argue that this is the first study to adopt RBV to explain the importance of metaverse capabilities as significant assets of retailing organizations. The results also help in understanding how to achieve an effective "digital transformation" from online retailing to metaverse retailing. This transformation requires both organization's resources and technology capabilities (Elia et al., 2021), with the latter encompassing spatial computing and decentralized technology capabilities. Resources must be developed concurrently so that the skills created by integrating them can be exploited to gain a sustainable competitive advantage (Brofman Epelbaum & Garcia Martinez, 2014).

ii. The application of PLS-SEM could aid in the analysis of the relationships between organizations' resources and capabilities, as well as their impact on the performance of retail companies. This methodology may aid in determining which factors are important for gaining a competitive advantage, as well as how they can be used to improve product innovation. The adoption of the metaverse necessitates a thorough understanding of the resources and capabilities required to succeed in this new environment by retail companies. The use of PLS-SEM may assist in empirically testing the relationships between these variables and product innovation and long-term competitive advantage. Retail companies can gain valuable insights into the factors that are critical for success in the metaverse by leveraging these resources and developing strategies to improve their performance in this new and rapidly changing environment.

iii. The research builds on previous literature in the context of innovation adoption by exploring the attributes of the technology based on user-based evaluation; which has been rarely explored in the context of metaverse adoption and has been restricted to a limited number of studies (e.g. (Akour et al., 2022; Chan et al., 2014)). We argue that as an emerging topic; there

is a need to explore this topic in different ways and by focusing on several attributes that have not been explored in previous literature.

7.2. Practical Contribution

i. Even though the moderation impact of the sustainability commitment was rejected, this study stresses the significant impact of sustainability awareness and commitment in metaverse adoption. Sustainability awareness and commitment are becoming increasingly important factors in organizations' attitudes and behavior toward new technologies (Aboelmaged & Hashem, 2019; Ayuso, 2006). Retail companies are more likely to support and adopt technologies that align with their sustainability values and beliefs. Sustainability awareness can lead to concerns about the environmental impact of the metaverse. The energy consumption required to power the servers and data centers that support the metaverse can have a significant carbon footprint. Retail companies that are environmentally conscious may have reservations about supporting a technology that has a negative impact on the planet. Sustainability awareness and commitment can also drive a desire for innovation and progress. Companies that are committed to sustainability may be more likely to support the development of technologies that have the potential to reduce environmental impacts or promote ethical behavior. In this sense, the metaverse may be seen as an opportunity to explore new ways of connecting and engaging with others while minimizing negative impacts on the planet. An example of this is the initiative supported by the SDGs (SDG Metaverse Prize, 2023), aiming to examine novel strategies for enhancing education and raising awareness of the SDGs using cutting-edge immersive innovations and inventive digital art.

ii. The implementation of cutting-edge technology is essential for businesses for a variety of reasons. New technologies are frequently developed to automate manual tasks and simplify complex procedures, which ultimately results in increased productivity and efficiency (Abri & Mahmoudzadeh, 2015). Because of this, there is a potential to reduce turnaround times and costs and increase productivity. Second, retail companies that adopt cutting-edge technology such as the metaverse will be able to stay ahead of the curve and offer superior products or services compared to their competitors. In addition, retail organizations will be more open to innovating and exploring new business models through the use of the metaverse. Additionally, the metaverse allows retail companies to connect with new customers regardless of their physical locations and accordingly grow their customer base, boost their sales, and increase their share of the market.

iii. The metaverse offers a novel platform that enables retail companies to engage with customers and enhance their shopping experiences. Companies may develop dynamic and appealing retail settings that captivate and please customers by utilizing the special features of the metaverse, such as lifelike simulations, tailored interactions, and seamless integration of virtual and physical retail spaces. Customers will be able to shop for products and make purchases in a completely immersive atmosphere. In addition, retailers can provide more personalized shopping experiences by making use of customers' data that is stored within the metaverse. Customers, for instance, can have avatars based on their preferences, and they can be presented with products that are more likely to pique their interest. Further, customers may be able to visualize products in 3D through the use of the metaverse. This provides them with the opportunity to examine the product from a variety of perspectives and gain a deeper comprehension of its qualities and advantages. Moreover, customers will be able to enjoy a more social and interactive shopping experience if they can do their shopping in the metaverse

with their friends. This can incentivize customers to remain in the virtual store for longer times, which in turn increases the likelihood that they will make a purchase.

iv. Security and privacy are critical for retailers to attract customers because they play an important role in establishing trust and credibility with customers (Belanger et al., 2002; Tsai & Yeh, 2010). Security and privacy concerns must be taken into consideration from the beginning of the design process (Di Pietro & Cresci, 2021; Gupta et al., 2023). Customers want to know that their personal information is secure and that their privacy is respected when they shop in a physical store or online (Huang et al., 2004). The success of the metaverse platform as a new technology for retail companies relies heavily on the platform companies' ability to effectively address security, privacy, and trust issues (Gupta et al., 2023). In addition, the metaverse may offer criminals more opportunities to carry out social engineering, scams, fraud, and other forms of cybercrime. These attacks could be more sophisticated and harder to detect. Therefore, it is essential to include user privacy and security as foundational design elements rather than add-ons (Gupta et al., 2023). Further, any security breach or denial of service in the metaverse might have real-world consequences (Gupta et al., 2023). The metaverse can earn users' trust and confidence and ultimately encourage widespread adoption by implementing strong security and privacy measures, providing transparency about data collection and use, and giving users control over their personal information. Furthermore, security training plays an important role in securing the metaverse and will remain crucial in ensuring overall security. Currently, employees in organizations are mainly trained to identify phishing emails. However, in the context of the metaverse, advanced training will be required on how to verify the identity of avatar users, detect virtual world scams, and other security concerns.

v. For retail companies to successfully adopt and implement metaverse technologies, advanced infrastructure is required. Retail companies must invest in reliable and high-performance infrastructure, such as powerful servers, high-speed internet connectivity, and advanced graphics processing technologies, in order to provide a seamless and engaging virtual experience for customers. Furthermore, advanced infrastructure can enable businesses to create more sophisticated and immersive virtual experiences, which can help in distinguishing the company's virtual offerings from competitors. However, implementing advanced infrastructure can be a complicated and expensive process that necessitates careful planning and expertise. Retail companies should therefore collaborate closely with experienced technology partners to ensure the successful implementation of advanced infrastructure and the optimization of their virtual operations.

8. Conclusion, limitations, and future research

The idea behind the metaverse is to create a completely immersive virtual environment where users may interact with each other and virtual things in a way that is virtually unrecognizable from reality. This would provide a level of interactivity and connectivity that is greater than what is now available with current digital technologies. The metaverse is anticipated to have a significant impact on several industries, including retail. This study investigated the variables influencing the adoption of a metaverse in the retail sector. The relationships between the researched components and attitude toward the metaverse, attitude toward the metaverse and intention to use, intention to use the metaverse and product innovation, and product innovation and sustainable competitive advantage were investigated using a research model built on the RBV theory. The model was assessed from 405 retail companies in Malaysia. The result showed that several factors are

important in the adoption of the metaverse by retail companies. The results of our study showed that perceived security and privacy concerns and perceived complexity negatively influence attitudes toward the metaverse. In addition, spatial computing and infrastructure positively influence attitudes toward the metaverse. Furthermore, sustainability awareness positively influences sustainability commitment. The study results rejected the impacts of the perceived cost on the attitude towards the metaverse and the decentralized technology on the attitude towards the metaverse. Regarding the moderating impact of sustainability commitment; sustainability commitment does not moderate the relationship between attitude toward the metaverse and intention to use the metaverse. Still, an additional relationship has been supported by the results of the analysis; which indicates that sustainability commitment impacts the intention to use the metaverse. The results of the study indicated that there are significant relationships between the attitude towards the metaverse and the intention to use the metaverse, the intention to use the metaverse and product innovation, and product innovation and sustainable competitive advantages.

In presenting the above discussion, it is necessary to acknowledge some potential limitations which should be taken into account in future studies. The first is that this study has considered the respondent from retail companies, in which we did not consider company size as a moderator. For our research model, other variables such as type of company, size of company, and familiarity with metaverse could be relevant but were not included in this study as influential variables. Specifically, different levels of familiarity can affect customers' beliefs, attitudes, and behaviors in adopting the metaverse, which could be taken into account in the development of the research model. In addition, it is critical to evaluate the adoption level of metaverse from the adopter and non-adopter perspectives in retail companies. Accordingly, future research can expand the proposed model focusing on these variables and providing empirical evidence from the adopter and non-adopter perspectives. Furthermore, future research on the use of metaverse technology in retail may look into how different types of virtual experiences influence consumer behavior and decision-making. It may also be worthwhile to investigate the role of social interaction within the metaverse, such as the impact of peer recommendations and the potential for virtual communities to drive loyalty. Finally, the relationships and the factors in the model can be further analyzed by combined techniques such as PLS-SEM (Wong et al., 2022) and neural network techniques, and Multi-Criteria Decision Making (MCDM) approaches (Deveci, Gokasar, et al., 2022; Karagoz et al., 2020). For future research, it is suggested to consider qualitative approaches such as interviews alongside the online survey used in our study. This mixed methodology would provide a deeper understanding of participants' perspectives, motivations, and experiences. Interviews allow for in-depth exploration and can uncover nuanced insights not captured by surveys alone. Combining both methods would enhance the comprehensiveness and validity of the study. This approach would overcome some of the limitations posed by the cross-sectional nature of the data employed, leading to a better understanding of the topic (Maier et al., 2023). We acknowledge the necessity to address any gender imbalances and other relevant demographic factors in upcoming research projects in order to achieve a more thorough study. Even though the current study's main objective was to examine the effects of specific interventions rather than examine gender as a control variable, it is significant to take gender balance into account in future research studies.

Appendix A

Table 1. Survey Items

Attitude toward Metaverse		
AM1	I have a favorable opinion of the metaverse.	(Polas et al., 2023)
AM2	The retail industry can benefit from the use of metaverse technology.	
AM3	The retail industry with metaverse innovation can be a fulfilling experience.	
Decentralized Technology Capabilities		
DET1	Real-world business can be carried out in a virtual space using metaverse technology in a decentralized manner.	(Mourtzis et al., 2022)
DET2	Retailers can trade ownership of virtual reality world investments using the metaverse in a decentralized manner.	
Intention to Use Metaverse		
IM1	The retail industry will be using the metaverse innovation in the future.	(F. Yang et al., 2022)
IM2	I will always try to use metaverse technology in my business.	
IM3	I intend to continue using the metaverse innovation in order to improve my business performance.	
Infrastructure		
INS1	Metaverse supports low-latency networks	(Huynh-The et al., 2023)
INS2	Metaverse supports access to cloud computing infrastructure for providing services.	
Perceived Complexity (Reverse Scale)		
PC1	Using a metaverse is an easy task with tolerable challenges.	(Akour et al., 2022)
PC2	Using a metaverse entails easy data collection and configuration processes.	
PC3	Overall, using the metaverse can decrease my workload.	
Perceived Cost		
PCS1	The cost of adopting the metaverse would be prohibitively expensive for our businesses.	(Zainab et al., 2017)
PCS2	The cost of maintaining the metaverse would be prohibitively expensive for our businesses.	
Product Innovation		
PIN1	Metaverse is constantly being updated with innovative capabilities.	(Kuncoro & Suriani, 2018)
PIN2	Metaverse capabilities are completely different from other innovations.	
PIN3	Metaverse features are completely different from other innovations.	
Perceived Security & Privacy Concerns (Reverse Scale)		
PSPC1	I am not worried that my data on the metaverse may be misappropriated.	(Dinev et al., 2008)
PSPC2	I am confident that my data on the metaverse would be used as anticipated.	
PSPC3	I am sure that my data on the metaverse would be protected.	
Sustainability Awareness		
SUSA1	Human behavior has had a major effect on the environment.	(Liobikienė & Poškus, 2019)
SUSA2	When humans interact with the environment it often generates dire effects.	
SUSA3	Human interaction with the environment has vital impacts	
Sustainable Competitive Advantage		
SCA1	Product uniqueness	(Kuncoro & Suriani, 2018)
SCA2	Competitive price	
SCA3	Product Quality	
Spatial Computing Capabilities		
SPC1	Spatial computing in the metaverse allows easy facility management.	(Shekhar et al., 2015)
SPC2	Spatial computing in the metaverse allows the interaction between digital objects.	
SPC3	Spatial computing in the metaverse allows interaction with the physical world more intuitively.	
Sustainability Commitment		
SUSC1	I will be disappointed if I do not implement sustainable behaviors at work.	(Safari et al., 2018)
SUSC2	Using environmental strategies at work gives me great satisfaction.	
SUSC3	I will feel guilty if I don't embrace environmentally friendly practices at work.	

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Data availability statements

The datasets generated and analyzed during the current study are not publicly available due the fact that they constitute an excerpt of research in progress but are available from the corresponding author on reasonable request.

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