Metaverse in Marketing and Logistics: The State of The Art and The Path Forward

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Abstract

Purpose: Ever since its emergence, the metaverse has presented opportunities and disruptions to every stakeholder, including individual users and organizations. This article offers valuable perspectives on six identified critical areas that the metaverse could significantly impact: marketing ethics, marketing communication, relationship marketing, retail marketing, supply chain management, and transportation management.

Design/methodology/approach: Through a multi-perspective approach, this paper gathers valuable perspectives from various invited contributors to each of the six identified key areas that the metaverse could significantly impact.

Findings: For each key area identified, the invited contributors first share their valuable perspectives by discussing the roles of the metaverse. Subsequently, the invited contributors discuss their views on vital opportunities, challenges, and research agenda concerning the metaverse.

Originality: With the widespread metaverse, it is expected that each key area identified is likely to undergo significant levels of disruption. Against this backdrop, this paper contributes to the academic literature and industry by gathering different perspectives from invited contributors on the relevance of the metaverse in marketing and logistics domains.

Keywords: Metaverse; marketing; logistics; supply chain management; virtual reality; extended reality; augmented reality; 3D virtual world; mixed reality; Web 3.0; digital world; avatars.

Article classification: Viewpoint.

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1. Introduction

As the digital landscape evolves, the metaverse emerges as the game-changing frontier for businesses worldwide. Ball (2022, p. 57) defined the metaverse as "a massively scaled and interoperable network of real-time rendered 3D virtual world that can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments". The CEO of Nvidia, Jensen Huang, has defined the metaverse as a 3D extension of the Internet and expects the real-world economy to be surpassed by the virtual (i.e., metaverse) economy (Forbes, 2022). Existing research mainly aligned metaverse to extended reality (XR) environments that utilize 3D, virtual reality (VR), and mixed reality (MR) technology to provide an immersive and shared experience using avatars (Dwivedi *et al*., 2022a). In essence, the metaverse constitutes a transcendent realm that integrates physical reality and digital virtuality, aiming to facilitate a rich and enduring multiuser experience (Mystakidis, 2022).

Interactive and gaming platforms such as Second Life and Roblox offer users a metaverse-like experience through VR headsets within an extended reality environment, allowing users to experience great degrees of interaction and immersion (Gent, 2022). Authors of extant literature have discussed the future potential of the metaverse, articulating a vision of a new ecosystem that has been described as an MR-based, future generation of the Internet that intertwines blockchain technology, digital assets, and avatars, where its users could enjoy seamless interactions with each other virtually (Dwivedi *et al*., 2022a).

The metaverse can potentially disrupt many aspects of people's work and lives, following more functions, tasks, and experiences enabled in the metaverse (Buhalis *et al*., 2023). As part of a review of the economic implications of the metaverse, Goldman Sachs estimates that about 15% to 33% of the digital economy could migrate to the metaverse, potentially expanding into a $12 trillion opportunity (Goldman Sachs, 2021). Brands actively explore the virtual space to identify future business opportunities within the metaverse. Gucci's foray into the digital realm of the Roblox platform in 2022 introduced a simulated iteration of the iconic Gucci Garden, located in the illustrious city of Florence, Italy, and ultimately amassed a staggering 20 million visits (Roblox, 2021). As the metaverse unfolds as a revolutionary platform for brands to engage with consumers, businesses need to reevaluate customer personas and journeys (Shen *et al*., 2021). Substantial challenges are anticipated for both individual users and organizations across business, societal, and regulatory aspects.

Whilst the metaverse concept has garnered considerable attention as a promising prospect for the domains of marketing and logistics, research lacunas persist within the academic literature and industry pertaining to the adoption and integration of the metaverse. The absence of a cohesive understanding has compelled marketing and logistic scholars to initiate research endeavors in the realm of marketing within this emerging digital space, encompassing scholarly inquiries that seek to elucidate the role of the metaverse in specific subfields of marketing and logistics (Barrera and Shah, 2023; Dwivedi *et al*., 2022a). The objective of this article is to address the research question: What are the opportunities, challenges, and future research agenda concerning metaverse in marketing and logistics?

This article follows a multi-perspective approach (Dwivedi *et al*., 2021ab; 2022abc) to offer valuable perspectives within several key areas of marketing and logistics that the

metaverse could significantly impact: *marketing ethics, marketing communication, relationship marketing, retail marketing, supply chain management, and transportation management.* The marketing and logistics domains will likely undergo significant levels of disruption within the metaverse, in the taxonomic aspects of hardware, software, contents, user interaction, implementations, and applications (Park and Kim, 2022). We position this article within the emerging literature that aims to develop meaningful insight into the key opportunities and challenges for marketing and logistics domains.

The remainder of this study is as follows: section two discusses marketing ethics in the metaverse. Sections three and four discuss marketing in the context of communications and relationships, respectively. Section five articulates the relevance of metaverse in retail. Sections six and seven discuss the role of the metaverse in supply chain management and transportation management. Each section includes the overview, opportunities, challenges, and research agenda presented by the invited authors, as shown in Table 1. The final section concludes the article.

Insert Table 1 Here

2. Metaverse and Marketing Ethics

2.1 Overview

To provide a narrow focus on how the metaverse is related to marketing ethics, we call attention to the metaverse that happens at the intersection of Web 3.0, which is built on blockchain architecture and enables an unprecedented level of decentralization (Mourtzis *et al*., 2023; Tan and Saraniemi, 2022). The fundamental principle underlying Web 3.0 is characterized by open, interconnected, and intelligent websites as well as web applications. The Web 3.0 paradigm aims to offer users enhanced control over their data generated online (Mourtzis *et al*., 2022). This section presents a new research direction in the realm of marketing ethics, focusing on decentralized trust. The co-determined decentralized trust emerges when social movement groups, environmental advocates, businesses, and communities collaborate from the ground up, forming interdependent properties and jointly establishing decentralized networks dedicated to ethical marketing practices.

2.2 Opportunities

The Web 3.0 metaverse projects, such as Decentraland and Orthoverse are a fully decentralized world built on the Ethereum blockchain. In this sense, any user can immerse himself or herself in the virtual world by visiting a three-dimensional virtual platform without the need to disclose personal information (Tan and Saraniemi, 2022). Investors can invest virtual plots of land in the platform without registering themselves with land authority, whereas developers can create metaverse apps that are not limited to a single cloud server but are instead distributed on a blockchain or decentralized network that is not controlled by a central authority (Christodoulou *et al*., 2022). Thus, the blockchain-based metaverse offers a new model of economic coordination and governance in the economy, especially in decentralized marketing management that focuses on societal value (Tan and Salo, 2023). Notably, blockchain technology, as an integral part of metaverse platforms, provides a decentralized and open record of transactions. Thus, within the realm of the metaverse, consumers can monitor and confirm the legitimacy of various marketing claims and transactions (Tan and Salo, 2023). Furthermore, from an ethical marketing point of view, metaverse can potentially improve the accessibility of marketing content and services,

particularly for people with special needs, thereby creating a more inclusive and ethical consumption experience.

2.3 Challenges

Although the Web 3.0 metaverse features decentralization and offers people the opportunity to collaborate, transact, perform, argue, and create as has never been seen before, bad actors can pervert the metaverse and use it as a tool to manipulate and radicalize users' trust and safety (Bourgi, 2022). For instance, a woman in the U.K. shared her experience of sexual harassment in the Horizon Worlds metaverse—her avatar was virtually gang raped and followed by derogatory comments—which caused emotional trauma (Shen, 2022). In responding to such challenges, how could decentralization serve to protect digitalized consumer mindset and enhance the trust of our society? In addition, the metaverse's immersive, real-time experiences may amplify existing social media and gaming issues, potentially increasing well-being concerns and thereby posing challenges for marketers to strive for a balance. Similarly, we expect the identity verification problem in Web 2.0 will intensify with broader metaverse usage (Mourtzis *et al*., 2022).

2.4 Research Agenda

Decentralized trust is a novel concept. To date, none of the articles exclusively explain what decentralized trust means and how to co-determine decentralized trust socially in the Web 3.0 metaverse. As indicated in Figure 1, in addition to the trust features inherent in blockchain-based exchanges (Tan and Saraniemi, 2022), the concept of decentralized trust should also encompass the impersonal trust placed in social movement organizations (Shapiro, 1987) – extensive networks of individuals or entities that concentrate on political and social concerns in the context of ethical marketing tactics. The reason given is that simply building trust on the blockchain is not enough to govern behavioral layers in the digital economy (Tan and Salo, 2023). Social movements foster effective management methods in the realm of ethical marketing, enhancing trust and collaboration while monitoring for potential collusion and exploitation (Arjaliès, 2010). Moreover, building decentralized trust should rely on enduring, non-exchangeable, yet revocable digital connections that signify pledges, qualifications, and associations, thus encoding the decentralized trust networks within the Web 3.0 metaverse economy. We emphasize *non-transferable non-fungible tokens* as it is the best technology that underlies peer-prediction theory (Miller *et al*., 2005) to maintain decentralization, provenance, and immutability, as well as to ensure security for access permission and data cooperatives in the Web 3.0 metaverse (Weyl *et al*., 2022).

Future research should be conducted to explore the creation of decentralized trust in the Web 3.0 metaverse, as well as open directions for the roles of marketing ethics in advancing research in the pseudonymous economy (Tan and Salo, 2023), decentralized identity (Tan and Saraniemi, 2022), and decentralized society (Weyl *et al*., 2022). Future research may explore how decentralized trust could lead to the creation of soft laws for consumer protection and consumer influence in the Web 3.0 metaverse.

3. Metaverse and Marketing Communication

3.1 Overview

The metaverse has been acknowledged as one of the game changers that revolutionized the marketing ecosystem. As we stand on the precipice of this digital frontier, the world of marketing communication is evolving in tandem, unlocking unprecedented possibilities for brands to captivate, interact with, and inspire consumers. The metaverse has been reported to significantly impact marketing communication (i.e., media, advertising, promotions, public and relations) that could help brands and businesses develop marketing strategies to ensure their promotional activities effectively reach their target market.

3.2 Opportunities

In terms of marketing communication, the rapid growth of online selling, especially post-COVID-19, has made the metaverse a vital tool for publicity and advertising programmes. For example, four-dimensional advertisements and virtual reality will allow consumers to interact intensively with products before buying them. This avenue will enable consumers to visit virtual stores to understand and experience products in detail. Apart from that, the metaverse also allows businesses and brands to reach out to their potential customers by placing their ads in the metaverse setting where customers engage. Similarly, digital advertisements and promotions in the metaverse empower businesses and brands to communicate the intended message ever-interactively. In addition to the publicity perspective, metaverse can help businesses in their marketing efforts by providing them with a platform for virtual tours and a virtual environment of their brick-and-mortar business. This setting could give consumers an immersive experience, allowing them to feel as if they are at the physical store.

3.3 Challenges

Extending the role of the metaverse for marketing communication purposes entails significant changes in the mode and medium of communication. In the metaverse world, marketers and brands are expected to create adverts that blend immersive visual, textual, and graphical content, which cannot be viewed with bare eyes but requires specific hardware (Park and Kim, 2022). However, the affordability and accessibility of AR and VR equipment remain rather limited, at least at the moment, which hampers the diffusion of metaverse applications in the marketing communication domain. Another challenge that may arise concerns the interoperability of the metaverse, wherein leading companies are building their virtual worlds in silos, resulting in competing metaverse platforms, each with its own proprietary protocol (Mourtzis *et al*., 2022). The challenges in relation to interoperability within the metaverse, and that between the metaverse and the real world may hamper the reach of marketing communication and pose difficulty to the integration of marketing communications.

3.4 Research Agenda

The metaverse has risen to the fore of the modern marketing communication landscape, and we believe that further research is needed to illuminate the relevance and build the capabilities of this emerging innovation for companies in interacting with consumers.

First, influencer marketing as a popular marketing communication tool deserves more attention in the transition to metaverse marketing. Influencer marketing is expected to be given a new life in view of the unprecedented immersive interaction made available between

influencers and audiences. The interaction mechanism transcends viewing content and following social media profiles, but a heightened engagement can be foreseen. According to the Communication Accommodation Theory (CAT) (Giles and Soliz, 2015), people modify their communication patterns to their communication counterparts. The avatar-based environment in the metaverse may result in a whole new way of interaction and communication. Further research is needed to understand the changes and effectiveness of influencer marketing as a marketing communication tool in the metaverse. How is influencer marketing in the metaverse valued? How do consumers process marketing messages in the metaverse through avatars (Kim, 2021)?

More interestingly, virtual influencers (artificial intelligence-based entities that mimic the characteristics and personalities of human influencers) may be the biggest shift in this transition (Sands *et al*., 2022). Brands are leaning toward cooperating with virtual influencers, and some of them (e.g., Prada) have created in-house virtual influencers for marketing communication in the metaverse. On the one hand, grounded in the uncanny valley hypothesis, it has been shown that consumers are facing considerable challenges in differentiating the virtual influencer from a genuine human being. Furthermore, consumers tend to experience a heightened sensation of eeriness toward virtual influencers (Franke et al., 2022). As a result, it remains to be seen whether the conventional influencer marketing practices are to stay or the rules are to be rewritten. Future research should be devoted to understanding the role of virtual influencers in the metaverse, their relationship development with metaverse audiences, and the endorsement effectiveness in the metaverse. It would be fruitful to compare the marketing communication role and performance of human and virtual influencers in the metaverse setting.

Second, given sensory marketing is grounded in the principles of feelings-as-information theory — creates emotional connections by engaging consumers' senses through visual, auditory, tactile, olfactory, and gustatory stimuli (Krishna and Schwarz, 2014), the metaverse is poised to enrich marketing communication, with multisensory inputs such as haptic feedback. Henceforth, several research avenues are worth further exploration: (i) How can companies manage communication effectively with additional sensory information that is limited relative to reality yet richer than that of the existing conventional digital media? (ii) Does the consumer shopping journey change in response to marketing messages in the metaverse? (iii) What are the possible changes in sensory marketing mechanisms in the metaverse?

4. Metaverse and Relationship Marketing

4.1 Overview

Relationship marketing involves and integrates the business stakeholders to benefit the organizational development and improve marketing performance (Ravald and Grönroos, 1996). Compared to the transactional marketing scenario, recent technological developments have helped relationship marketing build mutual interdependence and cooperation with the stakeholders in the virtual world, such as the metaverse. Metaverse is an empowered technology that can connect humans with the convergence of physical and digital realities (Dwivedi *et al*., 2022a). Human interactions involved in marketing and sales have been instrumental in fostering customer connections. It will be fruitful to observe how these interactions generate increased value within the realm of the metaverse. Building upon this background, the following sections discuss the opportunities, challenges, and research agendas in relationship marketing from a metaverse perspective.

4.2 Opportunities

The swift evolution of technology and the digital landscape has prompted marketers to adeptly harness diverse opportunities to formulate effective relationship marketing strategies. Unlike in the past, the avenues for firms to interact and engage with prospects have increased due to technological advancement. Similarly, the metaverse will allow marketers to have avatar-based interactions with their customers, generating value and experience on the same scale. Customer experience is recognized as an outcome of effective relationship marketing (Lemon and Verhoef, 2016). Likewise, the extended reality devices used in the metaverse browsing process can augment the interactive experience, thus contributing to a better outcome in the firm-customer relationship. The richness of data and behavioral tracking in the metaverse will enable business leaders to engage customers effectively and precisely when implementing their relationship marketing tactics. In sum, the metaverse has increased the relationship marketing scope, and firms need to better understand and align customers' preferences to develop tailored content and strategies in the new digital marketing environment.

4.3 Challenges

Though the opportunities for relationship marketing are wide open in the metaverse, the opportunities exist alongside significant challenges. The metaverse has provided multiple avenues for marketers to engage with stakeholders personally and through automated or AI-based communication or avatars as a replacement for physical embodiment. However, the effectiveness of using avatars or augmented technology to communicate and interact with customers remains unknown. Automated interaction is operationalized through a series of phases, from data collection to outcome processing, in which data has become a crucial partner in devising relationship marketing strategies. However, data and privacy are a cause of concern from the customer's and the government's perspectives. The concerns are amplified in the metaverse domain which operates largely on data-based social interactions, posing a threat to customer relationships (Steinhoff *et al*., 2019). To sum up, relationship marketing in the metaverse faces challenges in humanizing automated communications, ensuring transparent data and privacy policies, managing social interactions, and optimizing customers' purchase journey experience.

4.4 Research Agenda

In continuation to the above discussions, relationship marketing is a fertile ground that needs more research to uncover customer perceptions across digital mediums, especially with the emergence of the metaverse. Security and data threats are the primary concern in the relationship marketing scenario. Future researchers could explore this concern from data sharing intention, perception of opt-in communications in marketing, ethical data collection, lead generation exercises, and data repository access to third-party sources in the metaverse space. Customers' non-linear purchase journey across offline-online channels and digital devices has led to numerous constraints in implementing relationship marketing tactics. Thus, understanding customers' variant motivations underlying purchase journeys across metaverses is vital. The integration of metaverses is still in the exploration stage, so the data connectivity and following the customer journey in this cyberspace is yet to be explored. These explorations in research will aid marketers in developing appropriate relationship

marketing strategies. Accordingly, the following questions can be investigated; how do customers respect relationship marketing engagement in the metaverse at different levels of the purchase funnel, and how do customers perceive the communications across the metaverses intended from the relationship marketing perspective? How can human and avatar-based conversations be a part of relationship marketing strategies in the metaverse? Can it replace human aspects with similar efficiency?

5. Metaverse and Retail Marketing

5.1 Overview

The emergence of the metaverse has changed the way consumers shop online, encompassing how consumers, brands, and retailers interact and engage in the new digital reality (Barrera and Shah, 2023). Metaverse in retailing portrays the digital universe where consumers and their avatars can interact with brands and buy physical or digital products. According to RetailDive (2022), the metaverse is predicted to have an impact value between $8 trillion and $13 trillion by 2030. Given the potential, many retail brands have introduced their products and services on the metaverse to explore new business opportunities.

5.2 Opportunities

Consumer habits, behavior, and consumption are changing in the digital world (Shah and Murthi, 2021) as individuals find it easier to connect with retailers. According to eCommerceNews (2022), 25 percent of consumers will spend at least one hour daily in the metaverse by 2026. As consumers continue to recreate the resemblance of their physical lives in digital spaces by owning brands, there is an opportunity to replicate the online products known as the digital twins, replicas of physical assets in the metaverse that can help create more realistic and immersive digital experiences. With the metaverse, consumers can visit a store, browse through, and try digital products before purchasing the physical product. Dwivedi *et al*. (2022c) illustrated, for example, that consumers could try a range of outfits by allowing them to see how the products look together compared to trying them individually, which facilitates the decision-making process. Additionally, retailers can use digital twins to test new store layouts and merchandise displays by designing more appealing store layouts. According to Dwivedi *et al*. (2022a), IKEA, Dyson, and Forever 21 have started introducing their digital twins to allow consumers to experience the product before purchasing.

5.3 Challenges

While there are advantages associated with the metaverse, concerns also arise from its usage. Retailers can track customers' emotions and physical reactions by monitoring wearable and haptic devices, such as smart gloves and wristbands (Kliestik *et al*., 2022; Kovacova *et al*., 2022; Zvarikova *et al*., 2022). Dwivedi *et al*. (2022a) illustrated that eye-tracking technology could inform marketers about the type of products customers see, for how long, and the product placement most effective for sales. Barrera and Shah (2023) explained that the information captured could help identify customers' actions and emotions in real time. The enormous amounts of data collected can be misused by marketing organizations for targeted advertising and thus leading to privacy issues. Therefore, the data disclosed in the metaverse is a significant target for cyber-hackers.

5.4 Research Agenda

Traditional marketing and selling methods are no longer applicable in the metaverse. Retailers must rethink how to strategize their digital marketing campaigns in the metaverse. More research is needed to understand how consumers perceive and respond to retail messages and communication media to create more relatable, relevant, and personalized digital campaigns in the metaverse (Dwivedi *et al*., 2022d). As more data is collected from the metaverse ecosystem, there is a greater need to understand what data to prioritize. To implement digital targeting, Dwivedi *et al*. (2022c) suggested the usage of natural language programming, social networking analysis, and deep learning analysis. Also, it is important to understand how the available data can be used for marketing intelligence. Barrera and Shah (2023) shared that consumers connect with brands through online channels more efficiently. Many brands have started introducing their digital logos, memorabilia, and other intangible assets in the metaverse, but little research has been done to understand their roles in the metaverse environment. Therefore, further understanding of consumer motivation and how it affects the branding activities of retailers is needed. More research is required to understand consumers' personality traits, personas of consumers, attitudes, perceptions, purchasing behavior, and negative emotional patterns such as regret, anxiety, and addiction in the metaverse setting.

6. Metaverse and Supply Chain Management

6.1 Overview

A supply chain covers all activities involved in providing products and services required by customers. Supply chain management refers to the process of organizing, implementing, and overseeing the supply chain's activities. It includes all movements and storage of raw materials, work-in-progress inventory, and finished goods from the point of origin to the point of consumption to effectively meet customer demands (Govindan *et al*., 2017). Aimed to satisfy customer requirements as efficiently as possible, the digitization of supply chain management is inevitable as it helps to navigate and overcome uncertainty more effectively. Today, it has become almost impossible to talk about the digital supply chain without it being connected to Industry Revolution 4.0 (Ivanov and Dolgui, 2021). A digital supply chain is a set of supply chain processes that utilizes advanced technology to enable better insight into the function and status of each stakeholder along the chain for improved and accurate decision-making (Nasiri *et al*., 2020). Internet of Things (IoT), VR, AR, blockchain, and AI are trending technologies used in a digital supply chain. The latest addition to the list is the metaverse, which promises to transform supply chain management.

6.2 Opportunities

Metaverse in supply chain management enables businesses to better predict market changes, mitigate more risk, especially from the supply chain network, manage business performance, and make sound decisions based on a balanced view across growth, sustainability, and diversity (Scaff, 2022). This coincides with the concept of Supply Chain 4.0 coined by McKinsey, where the application of IoT, advanced robotics, and big data analytics in supply chain management significantly improve performance and customer satisfaction (Ben-Daya *et al*., 2019; Ivanov *et al*., 2018; Raman *et al*., 2018).

According to Accenture's Technology Vision 2022 report, 64% of supply chain executives believe the metaverse would benefit their companies, and that the challenges faced

in the global supply chain are about to change (Thompson, 2022). The Virtual Supply Chain (VSC) system, which creates a digitalized representation of the physical supply chain capable of mimicking every aspect of the supply chain, is ushering in the metaverse revolution into supply chain management, thus supercharging Supply Chain 4.0. Digital Twin technology, which is the fundamental enabler of the VSC. With AI and metaverse technology, VSC can inform businesses what happens if an action is taken or when something changes, as well as provide predictions and responses that optimize an operation as changes occur across the globe. With this, business operators can visualize what is going on, anticipate the future, and identify potential issues that may arise during demand changes, shortages, and other disruptions in the supply chain (Hadavi, 2022).

6.3 Challenges

However, the global supply chain is complex and difficult to comprehend. In order for the VSC to provide an accurate digitalized representation of the physical supply chain, the Digital Twins must be able to accurately capture the physical properties and real-time automatic updating of sensor readings to detect and resolve conflicts (Nguyen *et al*., 2022). In other words, the quality of the data supplied into the VSC system is critical. These data sources are the thousands of remote sensors spread across a distributed network. Hence, the reliability of the sensor network system, the sensitivity of the sensor, and the ability of the sensor system to stream accurate real-time data will make or break the VSC system.

Besides, data security and the technical capability of the operation team are concerns in implementing Digital Twins technology. With cybersecurity cases on the rise, data security becomes a critical aspect of supply chain management. Although the metaverse could adopt blockchain technology to maintain data integrity, security breach remains a considerable risk. This makes the battle to secure data in the cyber world even more important and critical. Therefore, technically capable firm members must maneuver and utilize this new revolutionary metaverse technology with caution.

6.4 Research Agenda

With so many prospects for the metaverse in supply chain management, ample research opportunities exist. To begin, one important research agenda would be the adoption of the metaverse by the various supply chain echelons, as well as the reasons why some operators are not embarking on the metaverse journey despite the benefits. Empirical studies could also be conducted to identify the metrics that would benefit a business the most during the metaverse transformation. The identification of the appropriate metrics aids in the formulation of the required data model for the prediction and recommendation algorithm. Another research area would be the mitigation strategy and resolutions for the challenges faced by firms of all sizes in adopting metaverse in the supply chain as well as the security and privacy issues in the metaverse. In a nutshell, researchers could help identify gaps in metaverse adoption and how supply chain management strategy in the metaverse should be formulated.

7. Metaverse and Transportation Management

7.1 Overview

Metaverse is an emerging topic in many disciplines (Dwivedi *et al*., 2022a), although it was coined long ago. Its early variants had been utilized in operations and logistics applications. One variant is Computer Automated Virtual Environment (CAVE), which has been widely cited as first developed by Cruz-Neira *et al*. (1992). CAVE is a virtual environment that utilizes virtual reality technologies to connect and simulate the physical environment. Typically, a CAVE uses visualization tools (such as projectors in the early days or 3D glasses recently) to display the virtual environment. More recently, digital twins have been developed for manufacturing and supply chain applications (Shen *et al*., 2022). NVIDIA Omniverse is an illustrative example (Liu *et al*., 2022). VanDerHorn and Mahadevan (2021) defined Digital Twin as "*a virtual representation of a physical system (and its associated environment and processes) that is updated through the exchange of information between the physical and virtual systems*". It is an advanced version of CAVE and is connected to the metaverse. The metaverse is poised to transform the world of transportation management by creating a virtual environment for seamless planning and execution of logistics, which requires further attention from transportation management scholars and practitioners.

6.2 Opportunities

Technology is constantly evolving. The accelerated pace of technology development nowadays (such as 5G technology and edge computing) is a significant driver for metaverse development. The metaverse concept is not brand-new, but it is about the right time to integrate various digital technologies to make it possible. Transportation and logistics could be one beneficiary of metaverses. The metaverse is expected to help optimize the processes, reduce operating costs, and, more importantly, connect different supply chain segments thanks to its connectivity nature. Deveci *et al*. (2022a) discussed how decision support systems would benefit from the metaverse to make better transportation decisions. For instance, the metaverse may facilitate transportation managers in creating and examining intricate transportation models within a virtual environment. Consequently, this can assist in the recognition of potential complications and obstructions, the evaluation of the implications associated with diverse transportation strategies, and the enhancement of infrastructure configurations prior to their implementation.

6.3 Challenges

The metaverse, embodying a digital realm, highlights the divide between digital and physical worlds. This gap is primarily attributed to the constraints of existing technologies. While the 5G mobile network surpasses its predecessors in terms of speed, it may still fall short in supporting 3D animations and high-definition videos crucial for decision-making processes. The latency between the digital and physical worlds is a specific measurement to gauge this disparity. Pamucar *et al*. (2022) defined a metaverse as "*a virtual universe where people connect and spend time*". Although it is not the universal definition of metaverses, it helps explain the linkage between metaverses and people. If the metaverse lacks a sense of human involvement (i.e., emotion and behavior), it is not much different from digital twins in production and transportation applications. In this sense, intelligence and learning capability represent essential elements in metaverses. That said, due to its dispersed nature, modeling such intelligence is not easy, not to mention the technological limitations above. A metaverse is a complex system and very likely cross-disciplinary. Implementing the metaverse for

logistics applications involves a certain degree of uncertainty. Obviously, the intelligence mentioned above could reduce this degree of uncertainty and its impact. That being said, the complexity of intelligence presents a significant obstacle to the development of the metaverse. How can a challenge cover another challenge?

6.4 Research Agenda

Regarding the previous section, it is apparent that trust is a significant issue in virtual environments, partly due to the lack of clear ownership in the metaverse. The legal systems from the physical world cannot easily be applied to this digital realm. However, blockchain technology may offer a solution. Data, by its very nature, drives the metaverse. However, data ownership remains a pressing issue, as does access to private data. Deveci et al. (2022a) have begun proposing blockchain-based metaverses in the production and logistics domain. Blockchain technology may address payment and other concerns within the metaverse. Despite the numerous studies on specific blockchain applications, linking existing chains in the metaverse is necessary. As a result, blockchain-as-a-service presents a significant research opportunity in the context of the metaverse and transportation management.

Another possible research paradigm is connected to the complex and uncertain nature of the metaverse in transportation management. To minimize the impacts of this uncertainty, there is a need to infuse intelligence into transportation management systems. In this context, intelligent algorithms, such as big data analysis, deep learning, fuzzy logic, and evolutionary algorithms, play a crucial role. For instance, Deveci *et al*. (2022b) employed fuzzy logic in a metaverse application to address autonomous vehicle decision-making challenges. Moreover, computational resources present a natural constraint to this paradigm, thus future research should be conducted to address this problem. Having the constraint resolved can enable significant improvement in the omnichannel distribution in logistics and transportation, thereby providing innovative solutions to pressing challenges in the sector.

7. Conclusion

In a nutshell, it is evident that the metaverse presents an unprecedented opportunity for marketing and logistics practitioners to revolutionize the industry. As the metaverse continues to evolve and expand, it is essential for businesses to stay abreast of the latest developments and leverage the technology to gain a competitive advantage. In the present study, we showed how by integrating metaverse into the marketing process and supply chain management systems, businesses could elevate their marketing performance and streamline operations. More specifically, we discussed different aspects of marketing (e.g., marketing ethics, retail marketing, marketing communication, relationship marketing) and logistics (e.g., supply chain management and transportation management) and proposed detailed opportunities, challenges, and future research agenda. Overall, the metaverse represents a new frontier in marketing and logistics, and authors of future studies can use the current study as a guideline to apprehend this novel technology and unveil latent prospects for research.

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