

UNDERSTANDING THE ROLE OF VIRTUAL REALITY AND METAVERSE PLATFORM IN DESIGNING RESILIENT AND SUSTAINABLE SUPPLY CHAIN NETWORKS

Witold Bahr^{1*}, Muhammad Mustafa Kamal², Azadeh Jafar Nezhad³, and Samer Muthana Sarsam⁴

^{1234*} *Coventry University, United Kingdom, ad4983@coventry.ac.uk¹, ad2802@coventry.ac.uk², ad8968@coventry.ac.uk³, and ad9429@coventry.ac.uk⁴*

** Corresponding author*

Purpose

Globally, from large scale to SMEs, businesses are keen to implement innovative technologies to overcome intricate and challenging issues related to their supply chain networks e.g., visibility and transparency of supply chains, complexity and interdependencies, non-availability of standards and metrics, lack of end-to-end seamless coordination and collaboration, etc. This research aims to investigate the potential utility of virtual reality (VR) and metaverse platforms to design resilient and sustainable supply chain networks. The study focuses on exploring how digital interoperability can be achieved through the integration of these technologies. To be competitive and sustainable, a supply chain needs to be resilient. Thus, this paper proposes a strategic partnership between VR and metaverse platforms to enhance supply chain resilience.

Research Approach

The study employs a qualitative research approach, involving an in-depth review of existing literature utilising the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach. The literature review will focus on identifying the key trends and challenges related to the integration of VR technology and metaverse platforms in supply chain networks, as well as the benefits and drawbacks of this integration.

Findings and Originality

The findings of the study suggest that the use of VR and metaverse platforms can significantly enhance the resilience of supply chain networks by enabling digital interoperability. Specifically, the study identifies several key design principles, such as the use of realistic simulations, immersive experiences, and collaborative decision-making tools, which can enable effective communication and coordination among supply chain partners.

Research Impact

The study has significant research implications, as it contributes to the growing body of knowledge on the use of VR and metaverse platform in supply chain management. The study highlights the potential of these technologies in enhancing supply chain resilience and achieving value chain synchronisation, which is becoming increasingly important in today's volatile and uncertain, yet competitive business environment.

Practical Impact

This study has important practical implications for supply chain managers and practitioners, as it provides insights into designing resilient supply chain networks using VR and metaverse platforms. The study also highlights the importance of digital interoperability in achieving supply chain resilience, which can help organisations mitigate supply chain disruptions and improve their overall efficiency and performance.

Keywords

Supply Chain, Resilience, Sustainability, Virtual Reality, Metaverse, Digital Interoperability

Introduction

In the information age, the role and impact of digital transformation in developing resilient and sustainable supply chain operations are increasingly attracting the attention of industry practitioners and scholars. Advocates believe that digital transformation has gradually metamorphosed governments and enterprises, into more competitive and driven, and providing several opportunities for economic growth and prosperity (Wan *et al.*, 2023; De Giovanni, 2023). In line with this change in approach and functionality, businesses are exhibiting a keen interest in adopting cutting-edge technologies such as virtual reality, artificial intelligence (AI), augmented reality, and big data, recognising their potential for profitable business applications (Bhandal *et al.*, 2022). Among the emerging technologies, the metaverse has garnered significant attention from the supply chain and business communities due to its promising features (Queiroz *et al.*, 2023). Cui *et al.*, (2022) advocates that the metaverse platform provides a comprehensive framework for the digital reorganisation of the entire supply chain system from R&D to customer service. Despite, the metaverse still is undergoing constant enhancements driven by various factors, including mobile-based always-on access and the integration of virtual currencies with real-world transactions.

This paper endeavours to design resilient supply chain networks by leveraging virtual reality and metaverse platforms, while considering the digital interoperability of operations. By adopting virtual reality and metaverse applications, there is a high potential for designing supply chain networks with robust connectivity options that enable direct and collaborative interactions with suppliers. This, in turn, can lead to reduced production costs and accelerated value chain synchronisation. The seamless and efficient communication between suppliers and customers fosters responsiveness and transparency throughout the entire supply chain. In doing so, the authors in this paper through a PRISMA based methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, Moher *et al.* 2009), identify the key trends and challenges related to the integration of VR technology and metaverse platforms in supply chain networks, as well as the benefits and drawbacks of this integration.

Literature review

Essentially, metaverse represents a vast virtual realm existing alongside the physical world, facilitating interactions through virtual avatars (Zainab *et al.*, 2022). Over time, the concept of the metaverse has been conceptualised in diverse ways, such as lifelogging, collective virtual space, immersive learning, embodied internet/spatial internet, digital twin, a mirror world, and an omniverse – a space conducive to cooperation and simulation (Park and Kim, 2022). Given its multifaceted nature, the metaverse has the potential to revolutionise several industries, including businesses and services sector, by opening up new sales channels and reaching untapped audiences, thereby boosting sales. In the metaverse, businesses can create digital replicas of their physical warehouses, enabling them to monitor inventory locations, stock levels, and detect potential issues (Dincelli and Yayla, 2022). This application can lead to cost reductions and improved operational efficiency. Furthermore, the metaverse has the capability to transform supply chain operations by facilitating more efficient collaboration with suppliers (Queiroz *et al.*, 2023; Polas *et al.*, 2022). Through the creation of virtual meeting spaces, businesses can engage in seamless collaboration with their suppliers on various tasks, ultimately streamlining operations and enhancing overall efficiency.

The proliferation of the metaverse – in academia and industry, particularly with the incorporation of virtual reality (VR), has led to a novel and transformative approach. VR entails immersive, three-dimensional representations of the real world or its constituent objects (Riva *et al.*, 2021). In a well-designed VR environment, users can interact with virtual settings through

its rich components, providing a valuable means of engagement. One of the distinct advantages of VR lies in its ability to facilitate repetitive training scenarios (Dincelli and Yayla, 2022). Unlike traditional real-world training, employees can engage in VR simulations multiple times to grasp concepts, tasks, or procedures effectively. This advantage holds significant potential for the development of modern business-related fields, positively impacting business quality, application, and processes (Chen and Yang, 2022; Allam *et al.*, 2022). A key domain that stands to benefit from these advancements is the supply chain (including all individual operations of production planning, procurement, internal and external logistics, inventory management), wherein various businesses collaborate to manufacture and deliver products to consumers (De Giovanni, 2023). Managing such a multifaceted supply chain network poses challenges in achieving a flexible supply chain. However, the extensive utilisation of current innovative technologies can bolster the supply network, enhance operating efficiency, reduce costs, and facilitate swift response strategies. For example, the metaverse can disrupt supply chains and related networks for two motivations. Firstly, metaverse through its platform will manage the transactions including governed by the blockchain technology – this will result in excluding the mediators within the supply chain (De Giovanni, 2022). Secondly, this platform can help develop new connections with other different suppliers e.g., the businesses that own the platforms, avatar designers, etc. (Vishkaei, 2022). In line with the latter, Queiroz *et al.*, (2023) argue that the current supply chain network arrangement can be redesigned and engineered in meta supply chains, which in turn will enable visibility, transparency, and trust among all entities to continuously optimise SC streams.

Methodology

To gain a comprehensive understanding of the existing literature regarding the role of virtual reality metaverse platforms in designing resilient and sustainable supply chain networks, a search query was constructed using the SCOPUS database. This query was formulated by adapting and expanding upon a set of keywords recommended by Setiawan and Anthony (2022). The selected keywords encompass 'virtual reality,' 'metaverse,' 'supply chain network,' 'supply chain,' 'sustainability,' 'sustainable supply chains,' and 'resilien*,' utilizing an asterisk as a wildcard to account for variations like 'resilient' and 'resilience.' To ensure the inclusion of exclusively peer-reviewed journal articles in the English language, search query limitations were imposed.

The process of literature selection followed the PRISMA four-tiered approach: identification, screening, eligibility, and inclusion. A search in the SCOPUS database yielded 18 articles that matched the specified queries. These articles underwent an initial screening based on their titles and abstracts, followed by evaluation of their full texts. To mitigate the potential for study selection bias during the screening and eligibility phases, a procedure akin to that outlined by Lim *et al.* (2013) was adopted. In this process, the two authors independently assessed the articles and resolved any discrepancies through deliberation and discussion until a consensus was reached. The literature selection process is depicted in Figure 1.

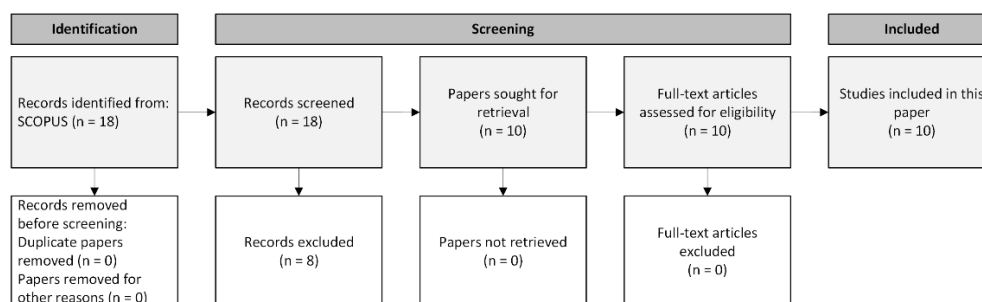


Figure 1: Literature selection process

Discussion of results

This study aims to understand the potential role of virtual reality and metaverse in creating a resilient and sustainable supply chain network. In this sense, an in-depth review of existing literature utilizing the PRISMA approach. The result showed that the metaverse facilitated virtual collaboration and communication among supply chain partners, which is essential to enhance decision-making and coordination. Besides, the result showed that the metaverse has the potential to offer virtual simulations and scenario planning that allow companies to test and optimize their supply chain strategies.

Metaverse is a virtual reality environment consisting of virtual reality elements in all aspects of place, time, and environment-human interaction. Similarly, virtual reality is a computer environment that creates multiple forms of virtual sensory responses, such as hearing and sight. It allows users to have a sensation of existence and absorption (Akram et al., 2022). In addition to the above-mentioned advantages, the metaverse is likely to gain popularity because of the rising acceptance of VR games, the availability of affordable VR devices for immersive experiences, and the application of traceable blockchain technology for safe transactions.

On the other hand, the integration of VR in the supply chain depends on the content of the business and industry. The fashion industry is one of the major industries that can benefit from the applications of metaverse and VR. It has been argued that VR assists in developing the personalized product and enhance customer online shopping experience by fostering retail experience through virtual features. This can happen through real-time visualization of smart cloth and garments on the virtual network. Thus, this supports our finding on the importance rule of digitalization in customizing users' needs and desires with the help of (Lăzăroiu 2022). Considering the higher interaction with users while using metaverse and VR compared to traditional online interactions, it could be more challenging to promise high security and manage risks including AR/VR devices, and compromised avatars and accounts in the metaverse. Consequently, it is important to use digitalization techniques to enhance business-related areas and establish strong platforms with low costs.

Limitations and future work

Despite its valuable contributions, this study is subject to several limitations. First, we reviewed articles related to virtual reality (VR) and metaverse platforms because these approaches are popular in the literature related to the design of resilient and sustainable supply chain networks. In the future, researchers could investigate the potential use of other digital technologies in the design of design resilient and sustainable supply chain networks. Second, in this study, we used the PRISMA approach since it is a popular method to perform an in-depth review of existing literature. Future studies could use another approach to gain further knowledge on the use of virtual reality and metaverse platforms in designing resilient and sustainable supply chain networks.

Conclusion

This research aims to investigate the potential utility of virtual reality (VR) and metaverse platforms to design resilient and sustainable supply chain networks. The key trends and challenges related to the integration of VR technology and metaverse platforms in supply chain networks, as well as the benefits and drawbacks of this integration. Therefore, we performed an in-depth review of existing literature utilising the PRISMA approach. Related articles were reviewed, and the result showed that metaverse facilitated virtual collaboration and communication among supply chain partners, which is essential to enhance decision-making and coordination. Besides, the result showed that metaverse has the potential to offer virtual

simulations and scenario planning that allow companies to test and optimise their supply chain strategies and processes in a risk-free environment. Besides, cost-related issues were found to be a serious issue with the use of immersive technologies at any stage of the fashion supply chain. As a result, this study proposes to discuss the strategic partnership between VR and metaverse platforms to enhance supply chain resilience.

References

- Akram, S. V., Malik, P. K., Singh, R., Gehlot, A., Juyal, A., Ghafoor, K. Z., & Shrestha, S. (2022). Implementation of digitalized technologies for fashion industry 4.0: Opportunities and challenges. *Scientific Programming*, 2022.
- Allam, Z., Sharifi, A., Bibri, S. E., Jones, D. S., & Krogstie, J. (2022). The metaverse as a virtual form of smart cities: Opportunities and challenges for environmental, economic, and social sustainability in urban futures. *Smart Cities*, 5(3), 771-801.
- Bhandal, R., Meriton, R., Kavanagh, R. E., & Brown, A. (2022). The application of digital twin technology in operations and supply chain management: a bibliometric review. *Supply Chain Management: An International Journal*, 27(2), 182-206.
- Cheah, I., & Shimul, A. S. (2023). Marketing in the metaverse: Moving forward—What's next? *Journal of Global Scholars of Marketing Science*, 33(1), 1-10.
- Chen, B. J., & Yang, D. N. (2022, October). User Recommendation in Social Metaverse with VR. *In Proceedings of the 31st ACM International Conference on Information & Knowledge Management* (pp. 148-158).
- Cui, Y., Idota, H., & Ota, M. (2022). Reforming Supply Chain Systems in Metaverse. *In Proceedings of the 9th Multidisciplinary International Social Networks Conference* (pp. 39-43).
- De Giovanni, P. (2022). Blockchain technology applications in businesses and organizations. IGIglobal. doi: 10.4018/978-1-7998-8014-1.
- De Giovanni, P. (2023). Sustainability of the Metaverse: A transition to Industry 5.0. *Sustainability*, 15(7), 6079.
- Dincelli, E. and Yayla, A. (2022). Immersive virtual reality in the age of the Metaverse: a hybrid-narrative review based on the technology affordance perspective. *The Journal of Strategic Information Systems*, 31 (2), 101717, doi: 10.1016/j.jsis.2022.101717.
- Lăzăroiu, G. (2022). Immersive virtual reality technologies, 3D data modeling and simulation tools, and artificial intelligence-based diagnostic algorithms on metaverse medical platforms. *American Journal of Medical Research*, 9(2), 57-72.
- Lim, M. K., Bahr, W., & Leung, S. C. (2013). RFID in the warehouse: A literature analysis (1995–2010) of its applications, benefits, challenges and future trends. *International Journal of Production Economics*, 145(1), 409-430.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group*. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, 151(4), 264-269.
- Park, S.-M. and Kim, Y.-G. (2022). A metaverse: taxonomy, components, applications, and open challenges. *IEEE Access*, 10, pp. 4209-4251, doi: 10.1109/ACCESS.2021.3140175.
- Polas, M. R. H., Jahanshahi, A. A., Kabir, A. I., Sohel-Uz-Zaman, A. S. M., Osman, A. R., & Karim, R. (2022). Artificial intelligence, blockchain technology, and risk-taking behavior in the 4.0 IR Metaverse Era: evidence from Bangladesh-based SMEs. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(3), 168.
- Queiroz, M. M., Fosso Wamba, S., Pereira, S. C. F., & Chiappetta Jabbour, C. J. (2023). The metaverse as a breakthrough for operations and supply chain management: Implications and call for action. *International Journal of Operations & Production Management*. Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/IJOPM-01-2023-0006>
- Riva, G., Di Lernia, D., Sajno, E., Sansoni, M., Bartolotta, S., Serino, S., Gaggioli, A. and Wiederhold, B. K. (2021). Virtual Reality Therapy in the Metaverse: Merging VR for the

Outside with VR for the Inside. *Annual Review of Cybertherapy & Telemedicine*, 19, 3-8.

Setiawan, K.D. and Anthony, A., 2022, August. The essential factor of metaverse for business based on 7 layers of metaverse—systematic literature review. In *2022 International Conference on Information Management and Technology (ICIMTech)* (pp. 687-692). IEEE.

Vishkaei, B. M. (2022). Metaverse: A new platform for circular smart cities. In *Cases on Circular Economy in Practice* (pp. 51-69). IGI Global.

Wan, X., Zhang, G., Yuan, Y., & Chai, S. (2023). Can metaverse technology drive digital transformation of manufacturers? Selection of evolutionary stability strategy based on supply chain perspective. *Applied Soft Computing*, 110611.