EVALUATION OF METAVERSE RISKS FOR SUPPLY CHAIN SUSTAINABILITY USING SPHERICAL FUZZY AHP

Ayça Maden
Beykent University, Industrial Engineering Department, Istanbul, Turkey

ABSTRACT

As a brand-new technology, metaverse attracts the attention of supply chains. Especially in virtual worlds, metaverse offers different features to supply chains with its accompanying technologies like virtual reality, blockchain, and artificial intelligence. However, to design a virtual world similar to the real world, different risks from the technological to social sides should be considered. In this study, the effect of metaverse risks on supply chain sustainability was investigated using a case study application. To do this, the spherical Fuzzy AHP method was used. Metaverse risks were determined using the literature review. After determining the weights of the metaverse risks, a selection was made between the supply chain sustainability dimensions over the determined risks.

Keywords: Metaverse, supply chain sustainability, risk

1. Introduction

Supply chain sustainability has economic, social and environmental dimensions. The contribution of new technologies to sustainable supply chains has always been a matter of curiosity. Since the metaverse is a very new technology, it should be investigated in detail for supply chain sustainability. Even unique characteristics of metaverse such as immersive realism, hyper spatiotemporality, sustainability, and heterogeneity may pose different risks like scalability and interoperability challenges in metaverse security (Wang et al. 2022). In this study, metaverse risks were evaluated for Sustainable Supply Chain Management (SSCM) using the spherical Fuzzy AHP method.

The rest of the paper is organized as follows. Section 2 reviews the literature, Section 3 outlines the Hypotheses/Objectives, Section 4 explains the Research design/methodology, Section 5 presents the Limitations, Section 6 outlines the Conclusion, and finally Section 7 outlines Key references.

2. Literature Review

2.1 Metaverse Risks

A modern metaverse platform should meet the following features: virtual world, persistency, scalability, decentralization, always-on with synchronicity, interoperability, security, and financial allowance (Huynh-The et al. 2022). In literature, there are different risks and challenges for metaverse although it is not widely adopted yet. The metaverse security threats can be classified into different dimensions like data, privacy, identity, network, economy, physical/social effects, and governance (Wang et al. 2022). In the large-scale metaverse, virtual worlds can be extremely heterogeneous in hardware implementation, communication interfaces, and software, which causes major

interoperability challenges (Wang et al. 2022). Metaverse has also limitations in hardware and software, development huddle, and sustainability dimensions (S. M. Park and Kim 2022). It is also important to establish specific standards for the metaverse which is closely connected to reality and has a multi-dimensional structure (Ning et al. 2021). The compatibility and standardization problems of the metaverse can be between metaverses generated by distinct companies or can be between metaverses and the real world (Ning et al. 2021). As another important risk, social acceptability indicates the metaverse users' behaviours, representing collective judgements and opinions of actions and policies (Lee et al. 2021). The social acceptability of metaverse is affected by various elements such as privacy threats, user diversity, fairness, cyberbullying, device acceptability, user addiction, cross-generational design, acceptability of users' digital copies, and green computing (Lee et al. 2021). For the metaverse to maintain a good and orderly ecological environment, it must control and restrict the behaviour of users, and it must have clear ethical and moral norms (Ning et al. 2021). Metaverse should satisfy some ethical and moral problems such as integrity issues, fraud, violation of intellectual property rights, and unfavourable atmospheres (Ning et al. 2021). Metaverse risks can be summarized in Table 1,

Table 1. Metaverse risks

Security and privacy threats (Wang et al. 2022), (Lee et al. 2021), (Ning et al. 2021), (Gadekallu et al. 2022), (Yang et al. 2022), (Nguyen et al. 2021)
Interaction problem (Ning et al. 2021)
Ethical issues (Ning et al. 2021)
Cyber-syndrome (Ning et al. 2021), (Lee et al. 2021)
Standards and compatibility (Ning et al. 2021)
Interoperability challenges (Wang et al. 2022), (Gadekallu et al. 2022), (Nguyen et al. 2021), (Dionisio, Burns, and Gilbert 2013)
Data, identity, and network-related threats (Wang et al. 2022)
Economy-related threats (Wang et al. 2022)
Physical safety/social effects (Wang et al. 2022)
Governance-related threats (Wang et al. 2022), (Yang et al. 2022)
Scalability challenges (Wang et al. 2022), (Dionisio, Burns, and Gilbert 2013)
Data acquisition, storage, and sharing (Gadekallu et al. 2022), (Yang et al. 2022)
Computation issues (Ning et al. 2021), (Dionisio, Burns, and Gilbert 2013)
Social acceptability (Lee et al. 2021)

2.2 Sustainable Supply Chain Management

Sustainability has three dimensions which are environmental, economic, and social sustainability. Social sustainability in supply chain management evaluates products and processes to determine the socioeconomic conditions of the people like safety, health, hygiene, wages, labour rights, and education (D'Eusanio, Zamagni, and Petti 2019; Mani et al. 2016). However, social sustainability in supply chain management is rarely studied although there is a growing interest in social sustainability (A. Park and Li 2021). Economic sustainability in supply chains mostly focuses on cost reduction, on-time delivery, reliability, and quality topics (Govindan, Khodaverdi, and Jafarian 2013). Supply chain sustainability over these environmental, economic, and social dimensions has become easier using new or developing technologies (Mangla et al. 2022). Technological

developments have become very important for SSCM to gain a competitive advantage and achieve SSCM performance (Kusi-Sarpong et al. 2021). Technologies for organizations and people could be translated into both opportunity and threat (Han and Rani 2022). Especially data-driven technologies created data security problems for the SSCM because of the difficulty in integrating various channels (Bachmann et al. 2022). Data security and privacy risks are extremely significant in the SSCM (Bachmann et al. 2022; Ozkan-Ozen et al. 2022). Although metaverse is not widely adopted between supply chains, its enabling technologies like blockchain and virtual reality can be inspected in detail, especially for its sustainability practices.

3. Hypotheses/Objectives

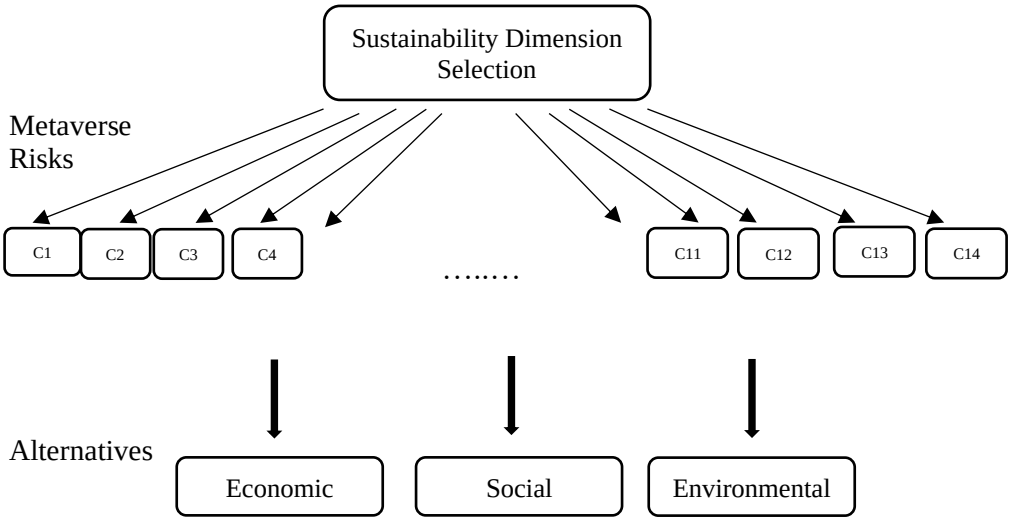
This study aims to determine which dimension of supply chain sustainability is most affected by metaverse risks.

4. Research Design/Methodology

The model in this study is based on information from a literature review and a pool of experts. Metaverse risks were determined using the literature review. In addition, alternatives were determined using the supply chain sustainability dimensions as economic, environmental, and social. Using the spherical Fuzzy AHP method, the most important supply chain sustainability dimension was determined in light of the weights of metaverse risks.

4.1 Spherical Fuzzy AHP

In this study, the spherical fuzzy AHP is used owing to its effectiveness. The steps of this method are followed using the methodology proposed by Kutlu Gündoğdu and Kahraman, (2020).



Fourteen metaverse risks were determined from the literature, which are: privacy and security threats (C1), interaction problem (C2), ethical issues (C3), cyber-syndrome (C4), standards and compatibility (C5), interoperability challenges (C6), data identity and

network related threats (C7), economy-related threats (C8), physical safety/social effects (C9), governance-related threats (C10), scalability challenges (C11), data acquisition, storage, and sharing (C12), computation issues (C13), and social acceptability (C14. A pairwise comparison of the metaverse risks according to the experts can be seen in Table 2,

Table 2. Pairwise comparison of the metaverse risks

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	EI	SMI	HI	EI	SMI	SMI	EI	SMI	HI	SMI	SMI	SMI	SMI	HI
C2	SLI	EI	HI	LI	EI	EI	SMI	HI	SMI	SMI	HI	EI	LI	HI
C3	LI	LI	EI	SLI	LI	LI	SLI	EI	EI	LI	LI	SLI	LI	EI
C4	EI	HI	SMI	EI	SMI	SMI	EI	SMI	HI	SMI	SMI	SMI	SMI	HI
C5	SLI	EI	HI	SLI	EI	EI	HI	HI	SMI	SMI	EI	SMI	SMI	SMI
C6	SLI	EI	HI	SLI	EI	EI	SMI	HI	SMI	SMI	HI	EI	LI	HI
C7	EI	SLI	SMI	EI	LI	SLI	EI	SMI	EI	SMI	HI	EI	SMI	HI
C8	SLI	LI	EI	SLI	LI	LI	SLI	EI	SLI	SLI	LI	SLI	SLI	SLI
C9	LI	SLI	EI	LI	SLI	SLI	EI	SMI	EI	LI	LI	SLI	LI	EI
C10	SLI	SLI	HI	SLI	SLI	SLI	SLI	SMI	HI	EI	SLI	SLI	SLI	LI
C11	SLI	LI	HI	SLI	EI	LI	LI	HI	HI	SMI	EI	EI	LI	HI
C12	SLI	EI	SMI	SLI	SLI	EI	EI	SMI	SMI	SMI	EI	EI	SMI	HI
C13	SLI	HI	HI	SLI	SLI	HI	SLI	SMI	HI	SMI	HI	SLI	EI	HI
C14	LI	LI	EI	LI	SLI	LI	LI	SMI	EI	HI	LI	LI	LI	EI

After calculating the weights of the alternatives, the social sustainability dimension was selected as the most important dimension for the experts considering the metaverse risks.

5. Limitations

The number of studies on metaverse is very few as it is a brand-new technology. As more studies are carried out, the contribution of this study will be confirmed. As metaverse technology becomes more widespread, especially for supply chains, the results found in this study will be more meaningful.

6. Conclusions

The examination of metaverse risks is important for its widespread use. Therefore, in this study, it has been determined which supply chain sustainability dimension is most affected by metaverse risks. According to the experts, the social sustainability dimension was the most important dimension considering the metaverse risks. In future, a detailed investigation of the advantages of metaverse applications in supply chains will be evaluated with the help of integrated MCDM studies.

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