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Digital Transformation in B2B Marketing: A Causal Network Analysis of Factors on the Metaverse

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Industrial metaverse, B2B marketing, decision-making trial and evaluation laboratory (DEMATEL), causal network analysis, digital transformation.

Objective: This study aims to bridge the gap in empirical research concerning the factors influencing the adoption of the "Industrial Metaverse" within Business-to-Business (B2B) marketing in developing economies. Specifically, it focuses on the Iranian industrial sector to model the complex causal relationships among the critical determinants of adoption.

Methodology: A sequential mixed-methods approach was utilized. First, a Delphi survey was conducted with ten industry experts to validate 25 sub-criteria categorized across five dimensions: Technological, Economic, Organizational, Social, and Legal/Regulatory. Subsequently, the DEMATEL technique was applied to quantify interdependencies between these factors and map the underlying causal network.

Results: The findings indicate that Organizational Factors are the most central and prominent dimension ($D + R = 17.796$), serving as a foundational driver. Technological ($D - R = +1.322$) and Economic ($D - R = +1.198$) dimensions emerged as primary causal variables, while Social ($D - R = -0.917$) and Legal/Regulatory ($D - R = -1.673$) factors were identified as dependent dimensions. At the sub-criteria level, Metaverse Cybersecurity ($D - R = +0.992$), Internal Digital Culture ($D - R = +0.812$), and Top Management Support ($D - R = +0.800$) demonstrated the highest causal power, whereas Technological Innovation Capability proved to be the most susceptible factor.

Conclusion: The study concludes that successful B2B Metaverse integration extends beyond mere technological acquisition; it fundamentally requires organizational readiness, a cultivated digital culture, and robust cybersecurity frameworks. Addressing legal and social vulnerabilities is contingent upon the maturation of these primary dimensions. By decoding the perceived structural dynamics of Metaverse adoption based on expert consensus, this research provides industrial managers and policymakers with a roadmap for optimizing resource allocation and fostering sustainable growth in the era of spatial computing.

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Introduction

The roots of marketing can be traced back to the earliest endeavors of offering products or services—a pivotal force that has consistently played a critical role in the success or failure of a business (Kotler, 2012). However, in the contemporary era, traditional marketing paradigms are no longer sufficient. Rapid technological transformations have fundamentally altered the modalities of interaction with customers and stakeholders (Barrera & Shah, 2023). Within this context, industrial marketing, or Business-to-Business (B2B) marketing, plays an indispensable role. B2B encompasses the exchange of goods and services among industrial organizations, including manufacturing firms, governmental subsidiaries, private sector entities, educational institutions, hospitals, distributors, and intermediaries. Unlike Business-to-Consumer (B2C) marketing, which targets individuals and households, B2B marketing is driven by organizational objectives such as further production, profit generation, and cost reduction (Chen et al., 2022). The B2B sector constitutes a massive portion of the global economy; notably, the global B2B payments market was valued at an estimated $87.98 trillion in 2024 (Fortune Business Insights, 2025). Reports indicate that this upward trajectory is heavily propelled by the emergence of Artificial Intelligence (AI) and overarching digital transformations, rendering the structural and operational adaptation of B2B enterprises to these shifts an absolute necessity (Lievens & Blažević, 2021).

Amidst these emerging technologies, the Metaverse has garnered significant attention due to its capacity to create multifaceted opportunities, such as enhanced business management, elevated customer engagement, and practical product demonstrations (Hollensen et al., 2023). Conceptually, the Metaverse refers to shared virtual worlds where users, represented by avatars, engage in commercial and social activities, acquiring boundless experiences (Jaynes et al., 2003). It provides unprecedented avenues for businesses and brands to solidify their digital presence and forge novel tiers of connectivity with their clientele (Shen et al., 2021; Dwivedi et al., 2023). Specifically, the "Industrial Metaverse" acts as a profound integrator of the physical and digital industrial realms. Grounded in data derived from the Internet of Things (IoT) and other Industry 4.0 enablers, it facilitates the 3D modeling and recreation of industrial environments. This paradigm shift effectively mitigates spatial and temporal constraints, thereby generating tremendous value for industrial stakeholders (Yao et al., 2024). In this trajectory, Fifth-Generation (5G) networks play a vital role in actualizing immersive, low-latency, and high-bandwidth experiences within these metaverse environments.

Despite the exponential growth of global research concerning the Metaverse—particularly focusing on Augmented Reality (AR), Virtual Reality (VR), consumer behavior, and AI (Sharma et al., 2025)—a comprehensive and systematic understanding of its opportunities and advantages within the B2B marketing sphere remains conspicuously absent. Many industries lack a holistic perception of the diverse opportunities generated by the Metaverse. Furthermore, despite its considerable potential, there is a profound lack of awareness regarding the causal roots and mechanisms driving the formation and expansion of these opportunities (Bamberger et al., 2025). The absence of a structured understanding of the complex, networked relationships among these factors can severely impede the effective exploitation of Metaverse capabilities. Moreover, while key themes have been identified globally, a scientific consensus on an integrated conceptual framework to elucidate marketing opportunities within this space has yet to be reached. This highlights an urgent need for a comprehensive study employing a causal-network perspective to identify emerging trends. Consequently, to bridge this salient research gap, the present study focuses on the causal-network analysis of factors influencing B2B marketing opportunities within the Metaverse. This approach is imperative for policymakers and industrial managers to pinpoint the sources of opportunities and delineate pathways for strategic improvement. The current research is of fundamental importance from two primary perspectives:

1. Theoretical Significance: For the first time in the context of B2B marketing within the Metaverse, the application of causal-network analysis (utilizing the DEMATEL method) provides a systematic framework for comprehending the complex, multi-factorial relationships between these opportunities and their foundational elements.
2. Practical Significance: Given the accelerating pace of technological evolution and the critical necessity of organizational adaptation to ensure survival (Pagani & Pardo, 2017), the findings of this research will empower B2B organizations and senior executives to formulate evidence-based strategies for the strategic exploitation of Metaverse advantages, ultimately expanding their market share (Kumar et al., 2026).

Thus, the primary objective of this research is the causal-network analysis of factors influencing industrial marketing opportunities within the Metaverse. This overarching goal is decomposed into the following sub-objectives:

- To identify the factors influencing B2B marketing opportunities within the Metaverse (through an extensive literature review and the Delphi method).
- To evaluate the degrees of influence and susceptibility of the identified factors (employing the DEMATEL method).
- To determine the interrelationships and conceptualize a structural model of factors impacting B2B marketing opportunities in the Metaverse (employing the DEMATEL method).

Literature Background

The Metaverse offers substantial advantages and benefits for businesses, particularly for marketing and sales departments. Within this immersive ecosystem, individuals and organizations can work, convene, accumulate assets, trade goods and services, and acquire novel experiences that were previously unattainable (Safitra et al., 2023). However, materializing these benefits—especially at the macro-industry and corporate levels—is not a frictionless endeavor, as it is fraught with multifaceted and diverse complexities. In the following sections, a review of the foundational concepts and a selection of prominent prior studies in this domain are presented.

Industrial and B2B Marketing

Industrial marketing, synonymously referred to as Business-to-Business (B2B) marketing, business marketing, or organizational marketing, encompasses the marketing of goods and services directed at industrial organizations. It defines a spectrum of activities wherein companies supply their products and services not to end-consumers, but to other organizations, manufacturing plants, or industrial entities (Wiersema, 2013). This marketing paradigm is an integral component of the industrial value chain, predominantly involving the sale of capital goods, heavy machinery, spare parts, raw materials, and engineering services. The fundamental nature of clientele in industrial marketing diverges significantly from the consumer sector (B2C); decision-making processes are inherently driven by rationality, operational requirements, and Return on Investment (ROI), rather than personal preferences or emotional triggers (Hall, 2022). In industrial markets, the customer base is generally smaller, yet the transaction volumes are exponentially larger. The target audience typically consists of large-scale organizations or specialized enterprises that undergo protracted evaluation processes prior to finalizing a procurement decision. Furthermore, cultivating enduring, long-term relationships between buyers and suppliers is of paramount importance. Consequently, industrial marketing places a pronounced emphasis on establishing trust, delivering tailor-made solutions, and providing robust technical support (Bamberger et al., 2025).

Industrial marketing draws upon diverse theoretical perspectives, incorporating insights from organizational theory, systems analysis, economics, behavioral sciences, and sociology (Achrol & Kotler, 2022). For instance, organizational buying behavior inherently involves human actions and reactions within a value-exchange framework. The components of the industrial marketing mix (product characteristics, pricing strategies, distribution channels, and promotional tools) are instrumental in shaping the choices of organizational buyers (Bilro et al., 2023). Moreover, buyer-seller dynamics in the industrial market are highly complex, predicated on long-term interactions, mutual trust, and collaborative synergy. These dynamics form the bedrock of "Relational Marketing," which invariably leads to sustainable competitive advantage, robust loyalty, and coinnovation (O'Malley, 2014). Committed industrial buyers demonstrate a propensity to procure in high volumes consistently and adopt a long-term perspective regarding the relationship, which in turn reduces the seller's operational costs and enhances overall procedural efficiency (Stanko et al., 2007).

The organizational procurement process is characteristically prolonged and involves multiple stakeholders, thereby fostering interpersonal relationships across two or more organizations. Figure 1 illustrates the taxonomy of industrial customers.

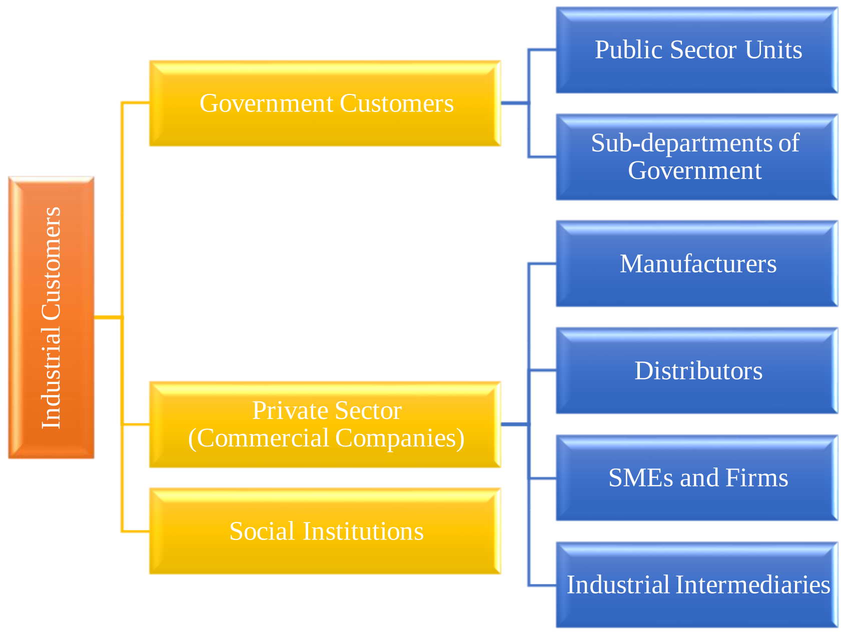

Figure 1. Taxonomy of Industrial Customers (Source: Authors)

The extensive applications of industrial marketing can be classified into seven primary domains:

- Manufacturing Industries: Supplying heavy machinery, automated production lines, spare parts, and raw materials.
- Energy and Infrastructure: Engaging contractors for energy generation and transmission, as well as providing refinery equipment.
- Information Technology (IT) and Digital Industries: Marketing enterprise software solutions (such as ERP and CRM) and providing cybersecurity services.

- Transportation and Logistics: Contracting urban logistics, aviation, maritime, and railway companies for manufacturers and exporters, emphasizing sustainable logistics.

- Engineering and Consulting Services: Securing engineering projects and providing industrial asset management.

- Agricultural and Food Industries: Selling agricultural machinery, smart irrigation systems, and additives to processing industries.

- Corporate Services: B2B service marketing, encompassing corporate catering and hospitality, diverse insurance portfolios, corporate financial and investment services, and other specialized services where the counterpart is an organization rather than an individual (Bussler, 2003).

Metaverse Technology

The Metaverse constitutes a convergence of augmented physical reality and simulated virtual space. Within the Metaverse roadmap, four fundamental elements have been categorized: augmented reality, lifelogging, virtual worlds, and mirror worlds (Kye et al., 2021). Zuckerberg (2021) conceptualized the Metaverse as an “embodied internet”—an online, materialized realm where individuals can work, play, and socialize in the form of avatars.

The precursors to the Metaverse were Multi-User Role-Playing Games (MURPGs) such as Second Life, which effectively introduced the paradigm of avatarism for the first time (Tavallaei & Ahmadi, 2015). However, in subsequent years, they did not garner the same magnitude of attention as the contemporary Metaverse (Wiederhold, 2022).

Within the organizational and corporate domain, the concept of simulation and digital representation of industrial and organizational processes possesses deep historical roots. Advanced design software, 3D supply chain and organizational environment simulators, as well as platforms operating on the principles of simulation and gamification, have for years recreated industrial operations in digital environments. These initiatives primarily aim to train personnel, mitigate operational errors, and optimize internal processes (Alikhanzadeh et al., 2020). Nevertheless, the objectives of these simulators were generally confined to the realm of engineering and internal operations. The created environments frequently lacked multi-user interoperability, a profound sense of immersion, and an intrinsic internal economy.

The Metaverse transcends conventional digital games or mainstream social networks; hence, five of its key characteristics warrant specific attention:

- Convergence of Virtual and Physical Worlds: This is the foundational characteristic of the Metaverse. Through it, the dichotomy between virtual and physical realities is bridged, rendering the user experience profoundly immersive and multi-sensory (Ritala et al., 2024).
- Instantaneous and Often Unrestricted Access: Supported by high-speed networks (5G and 6G) and wearable gadgets, users can instantaneously enter the Metaverse without spatiotemporal limitations (de la Fuente Prieto et al., 2022).
- Digital Identity: Every user can customize their unique digital identity in the form of an avatar. Facilitated by real-time tracking technologies, these user-controlled avatars play a pivotal role in ownership, interaction, and socialization within the Metaverse ecosystem (Saragih et al., 2011).
- Immersive and Multi-Sensory Experience: Live, modeled virtual scenes can induce a profound sense of immersion (Shin, 2022). Utilizing technologies such as VR, AR, and the IoT, users are empowered to interact with virtual artifacts, resulting in the intensive stimulation of multiple human senses (Jovanović & Milosavljević, 2022).
- Decentralized and Editable Content: The Metaverse grants every user the right to edit or generate content of a virtual nature. Furthermore, users can possess digital assets, utilizing technologies like blockchain to ensure the security and traceability of their personal attributes and properties (Vidal-Tomás, 2022).

Figure 2 schematically illustrates the key characteristics of the Metaverse.

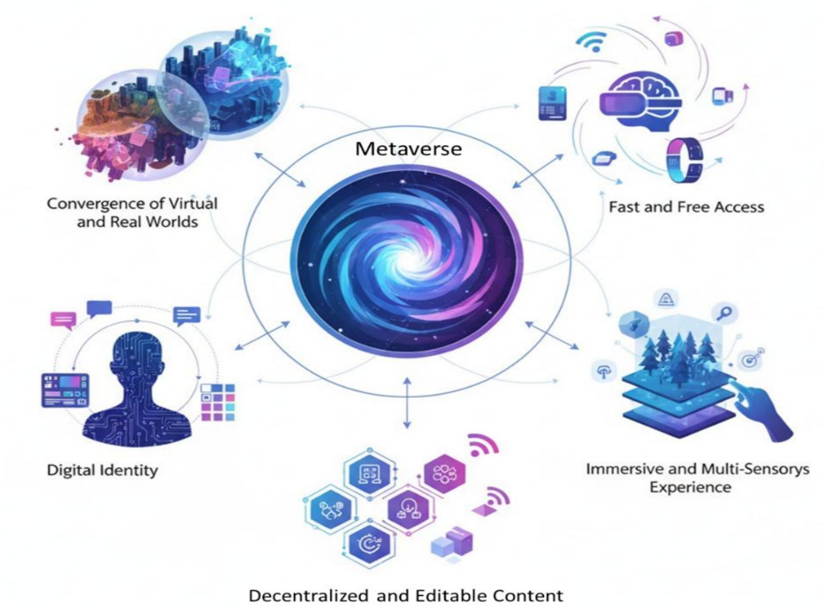

Figure 2. Key Characteristics of the Metaverse (Source: Authors)

The amalgamation of an array of modern technologies facilitates business virtualization and stakeholder customer-centricity within the Industrial Metaverse. These technologies act as the driving force behind the transformative impact of the Industrial Metaverse on B2B marketing. Among these foundational technologies, the following can be briefly delineated:

- Digital Twins: These are virtual replicas of physical entities that, fueled by sensor-generated and synthetic data, possess the capability to forecast future conditions and recommend optimal modifications (Rasheed et al., 2020).

- IoT: By aggressively collecting data and interconnecting devices, the IoT functions as the central nervous system of the Industrial Metaverse (Li et al., 2022).

- AI and Complex System Modeling: AI infuses intelligence into the decision-making process by rigorously analyzing data derived from the IoT and digital twins (Guo et al., 2022).

- VR/AR: These serve as the Human-Computer Interaction (HCI) interfaces with the Industrial Metaverse space, enabling simultaneous visualization of, and interaction with, simulated environments (Dhıllon & Tınmaz, 2024).

- Blockchain: Acting as both the immune system and the memory ledger of the Industrial Metaverse, blockchain revolutionizes the functionality of commercial ecosystems through the secure and transparent storage of transactional data (Huynh-The et al., 2023).

- Robotics: Ranging from 3D printing technologies to sophisticated chatbots, robotics is capable of translating digital instructions into physical actions and tangible artifacts (Gokce Narin et al., 2023).

The Industrial Metaverse: Opportunities and Realities

Today, B2B marketing operates within an environment characterized by unprecedented dynamism and uncertainty, demanding ever-increasing agility. The evolution of this domain has transitioned from a transactional focus to relationship-centric paradigms, and subsequently to network orientations. Presently, driven by technological convergence, it is pivoting towards cyber-physical environments, marking the dawn of the Industrial Metaverse era (Rust, 2020). The Industrial Metaverse is poised to be one of the most profound transformations in B2B marketing over the past four decades. This paradigm shift transcends mere digital connectivity; it fundamentally pertains to the virtualization of businesses and entire ecosystems. Virtualization, in this context, refers to the creation of virtual replicas of physical products, personnel, and processes that can augment, simulate, or supersede their tangible counterparts within the digital realm (Kshetri, 2023).

Although the lion’s share of attention in marketing literature has hitherto been concentrated on the consumer Metaverse (B2C), the potential of the Industrial Metaverse (B2B) is equally, if not more, substantial. Projections indicate that its total addressable market could be twice the magnitude of the consumer Metaverse (Lawton, 2022). The Industrial Metaverse focuses not exclusively on human-to-human interactions but inherently encompasses the complex interplay among products, individuals, processes, and holistic industrial systems. Over a decade ago, Wiersema (2013) presciently cautioned that virtualization technologies could instigate a revolution in B2B marketing, the impact of which might even eclipse that seen in the B2C sector.

Centered on B2B marketing, the Industrial Metaverse constitutes an integrated and dynamic ecosystem wherein digital twins, physical products, human actors, and operational processes interact synergistically, facilitating strategic planning based on sophisticated virtual simulations (Yao et al., 2024). This overarching space encompasses B2B marketing products, services, and processes, provided that a constituent part of these elements relies upon digital twins. These digital twins serve as advanced digital replicas of physical components, dynamically updated in real-time via IoT data streams, thereby forming the very bedrock of the Industrial Metaverse (Choi et al., 2022).

Review of Recent Research

In recent years, the Metaverse has emerged as a disruptive phenomenon, garnering significant attention across various scientific and industrial domains. These transformative shifts have exerted a particularly profound impact on B2B marketing, prompting researchers to vigorously investigate methodologies for leveraging Metaverse technologies to optimize marketing strategies. The prevailing corpus of literature predominantly focuses on the Metaverse’s impact on marketing dynamics, commercial relationships, and customer experience enhancement. A consensus is gradually forming that the adoption and implementation of these technologies can act as a catalyst for business process optimization and corporate growth. To provide a structured synthesis of the extant literature, the most salient recent studies are categorized into four primary thematic domains:

- B2B Evolution and Industrial Metaverse Implementation: Recent scholarship heavily emphasizes the paradigm shift within B2B contexts. Bamberger et al. (2025) articulated that rapid technological advancements and market fluctuations have engendered critical challenges for sustaining B2B marketing communications within the academic community. Tracing the evolutionary trajectory of this field from a transactional focus to relationship-centric models, and ultimately to virtualized business ecosystems, they assert that the Industrial Metaverse radically transforms the management of B2B transactions and relationships. Consequently, they advocate for academic research to aggressively align with industrial advancements to address emerging managerial challenges. Complementing this macro-perspective, Deleuze (2024) employed grounded theory to explore the practical implementation of the Metaverse within B2B marketing firms. His research delineated the associated benefits and challenges, culminating in the proposition of actionable frameworks for organizational readiness and technology adoption in the marketing sector.

- Practical Applications and Sector-Specific Virtualization: Several studies have investigated the deployment of Metaverse technologies as sustainable alternatives to traditional practices across various industries. In the retail and exhibition sector, Vangi et al. (2024) introduced the "Tangible Mixed Catalog"—an innovative amalgamation of a physical booth and a Mixed Reality (MR) application. This solution empowers retailers to browse apparel, customize material attributes, and receive real-time feedback. It is proposed as a viable, eco-friendly surrogate for physical exhibitions, preserving the sensory attributes of traditional showrooms while mitigating environmental impacts. In the tourism sector, Buhalis et al. (2023) examined strategic opportunities for Metaverse integration, suggesting that tourism organizations should architect hybrid (phygital) experiences to engage effectively with clientele across pre-, core-, and post-visitation phases. Furthermore, Sartamorn & Oe (2022) analyzed the technological impact of the Metaverse on Thailand's industrial sectors, providing strategic imperatives for utilizing this ecosystem to support small and medium-sized enterprises (SMEs) and local businesses.

- Customer Experience and Brand Engagement: The enhancement of the end-user journey remains a focal point. Hollensen et al. (2023) investigated the conceptual application of the Metaverse within major global brands (e.g., Nike), delineating its substantial benefits for consumers. Their findings indicate that virtual platforms exert a profound influence on elevating customer experience and brand interaction. Concurrently, Shen et al. (2021) analyzed the determinants influencing customer purchasing behavior within virtual worlds, identifying strategic opportunities the Metaverse provides for upgrading the shopping experience and offering targeted recommendations for consumer journey optimization.

- Theoretical Frameworks, Multidisciplinary Impacts, and Risks: A crucial segment of the literature is dedicated to mapping the conceptual landscape and identifying inherent vulnerabilities. Barrera & Shah (2023) addressed the urgent necessity for a deeper comprehension of the Metaverse's impact on marketing by proposing a systematic framework. This framework defines the Metaverse construct and outlines future research trajectories, underscoring the magnitude of marketing transformations. Abbate et al. (2022) conducted a bibliometric analysis to explore the Metaverse concept, identifying key research foci and prominent authors, thereby demonstrating how technological evolution has spurred the proliferation of diverse virtual platforms. Beyond the opportunities, researchers have rigorously analyzed the systemic challenges. Dwivedi et al. (2023) conducted a comprehensive multidisciplinary analysis of the Metaverse's impact across marketing, industry, education, and healthcare. Crucially, they scrutinized psychological dimensions, such as technology addiction and its detrimental effects on vulnerable demographics. Addressing cybersecurity concerns, Smaili & de Rancourt-Raymond (2024) investigated fraud-related risks within the Metaverse, proposing strategic countermeasures to prevent deceptive practices in this nascent virtual environment.

Synthesizing recent research elucidates that the Metaverse and its industrial counterpart function as highly innovative paradigms capable of fundamentally revolutionizing commercial interactions, customer experiences, and product/service development. While engendering unprecedented opportunities, these technologies simultaneously introduce complex challenges, thereby underscoring the imperative for continuous, longitudinal research to keep pace with digital dynamism. Ultimately, the judicious adoption and deployment of these technologies, coupled with a rigorous analysis of their market and consumer impacts, are inextricably linked to long-term corporate success and competitive advantage.

Research Gap

Prior studies have consistently underscored the profound significance and transformative potential of the Industrial Metaverse within B2B marketing, particularly through the lens of enabling technologies such as digital twins, blockchain, and Artificial Intelligence (AI). Nevertheless, a critical review of the extant literature reveals a salient limitation: contemporary research, specifically within the industrial marketing domain, has predominantly relied upon linear analyses or simplistic correlational paradigms. Consequently, there is a conspicuous absence of sophisticated analytical approaches—such as network-causal modeling—capable of mapping the intricate, multilateral, and feedback-loop relationships among B2B marketing indicators.

Furthermore, the lack of an integrated, holistic framework tailored to contemporary market dynamics and modern industrial architectures has resulted in a fragmented and uncoordinated understanding and utilization of the Industrial Metaverse's true capacities. Cumulatively, navigating the systematic integration of the Industrial Metaverse within B2B marketing necessitates empirical investigations that employ robust methodologies, such as the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique. Such approaches are imperative for identifying the structural and causal interdependencies among critical success factors, thereby laying the groundwork for evidence-based decision-making by policymakers and operational executives. Driven by the objective of conducting a comprehensive network-causal analysis, the present study explicitly seeks to bridge this identified research gap.

Materials and Methods

Research Design and Paradigm

The present study adopts an applied research paradigm, driven by the objective to furnish actionable strategies for industrial sectors to capitalize on B2B marketing opportunities within the Industrial Metaverse. Methodologically, a sequential mixed-methods design was employed. The qualitative phase utilized literature synthesis and the Delphi method to identify and screen the salient factors influencing industrial marketing in the Metaverse. Subsequently, the quantitative phase applied the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique to evaluate causal interdependencies and map the network structure among the finalized factors.

The epistemological stance of this research is rooted in realism, as it seeks to observe, describe, and analyze actual phenomena within a real-world context to identify critical marketing determinants. Furthermore, the research nature is inductive, formulating a comprehensive set of final factors based on specific data gathered from prior literature and empirical expert insights. A survey-based research strategy was implemented to collect primary data via structured questionnaires. Temporally, the study is cross-sectional, encompassing a one-year time horizon.

Participants and Sampling Strategy

The statistical population comprised distinguished experts and executives possessing substantial academic and practical acumen in B2B marketing and Metaverse-enabling technologies (e.g., VR, AR). To ensure the high validity of the acquired data, a non-probability purposive sampling technique was utilized. The inclusion criteria for the expert panel were rigorously defined as follows:

- A minimum of 3 years of direct operational experience in B2B marketing or industrial market development, complemented by at least 5 years of general professional experience.
- A verifiable academic or research background (e.g., publications, localized projects) pertinent to the Metaverse or its industrial applications.
- Proven managerial or technical expertise in deploying technological projects related to virtual platforms for industrial enterprises.

Based on these stringent criteria, a panel of 10 senior experts and executives was selected from two macro-industrial entities in Iran: Tavanir (Iran Grid Management Company) and the Ministry of Agriculture-Jahad.

The deliberate selection of these two macro-industrial entities is grounded in the economic structure of developing nations like Iran. In such contexts, governmental and quasi-governmental infrastructural organizations act as the primary B2B mega-buyers and trendsetters. The private sector predominantly functions as suppliers to these macroeconomic hubs. Therefore, extracting mental models from senior executives within these pivotal organizations provides the most reliable indicator of overarching B2B market trajectories and systemic readiness.

In multi-criteria decision-making (MCDM) approaches like DEMATEL, the reliance is on the profound knowledge of domain experts rather than the statistical law of large numbers. Hence, a sample size of 10 highly qualified experts is methodologically robust and scientifically justified for complex relational mapping.

Data Collection and Instruments

Data acquisition was conducted through comprehensive library research and the administration of two distinct survey instruments:

- Delphi Questionnaire: Designed to validate and screen the preliminary factors extracted from the systematic literature review.
- DEMATEL Questionnaire: Structured to assess the pairwise influence (causal direction and intensity) among the finalized factors, utilizing a 5-point Likert scale.

To ascertain the reliability and validity of the instruments, face validity was evaluated. The preliminary questionnaires were distributed to a smaller sub-group of highly accessible experts within the panel, and their feedback was incorporated to refine and finalize the ultimate survey structure.

Analytical Procedures

The gathered data were systematically analyzed employing the following qualitative and quantitative procedures:

- The Delphi Method: The Delphi technique is a structured communication process utilized to build consensus among a panel of experts regarding a complex issue. The procedural steps implemented in this study were:

1. Indicator Identification: Conducted via a comprehensive review of theoretical foundations and empirical literature.
2. Expert Evaluation: The decision-making panel (10 experts) evaluated the relevance of the identified indicators to the core research theme using a 5-point linguistic scale (from "Strongly Disagree" to "Strongly Agree").
3. Screening and Validation: An empirical threshold (S) was established at $\mu = 3.0$. Any indicator securing a mean score strictly less than 3.0 was systematically eliminated from the framework.
4. Consensus Measurement: Kendall's Coefficient of Concordance (W) was calculated using SPSS software to quantitatively verify the degree of consensus among the panel members.

- The DEMATEL Technique: Originally developed by Fontela and Gabus (1976), DEMATEL is a sophisticated Multi-Criteria Decision-Making (MCDM) methodology predicated on pairwise comparisons. It is designed to identify mutual relationships among criteria and construct a structural network map. This technique categorizes factors into "Cause" and "Effect" groups and quantifies the intensity of their interrelations. The mathematical modeling steps executed in this study are as follows:

1. Step 1: Constructing the Direct-Relation Matrix (M): Experts evaluated the pairwise influence of criteria using a Likert-based comparative scale (ranging from "No Influence" to "Very High Influence"). Let X^h represent the non-negative matrix provided by expert h. Since multiple experts ($H = 10$) were involved, the aggregated direct-relation matrix (M) was computed by taking the arithmetic mean of all expert matrices:

$$M = \frac{1}{H} \sum_{h=1}^{H} X^h \tag{1}$$

Where His the total number of experts, and M is an $n \times n$ matrix with elements m_{ij} denoting the direct influence of factor i on factor j).

2. Step 2: Calculating the Normalized Direct-Relation Matrix (N): The normalized matrix N is derived by multiplying matrix M by a normalization factor k:

$$N = k \cdot M \tag{2}$$

The factor k is calculated by taking the inverse of the maximum sum of absolute values of rows or columns, ensuring that the maximum sum in matrix N is equal to 1:

$$k = min\left(\frac{1}{max_{1 \le i \le n} \sum_{j=1}^{n} m_{ij}}, \frac{1}{max_{1 \le j \le n} \sum_{i=1}^{n} m_{ij}}\right) \tag{3}$$

3. Step 3: Deriving the Total-Relation Matrix (T): The total-relation matrix (T), which accounts for direct and indirect effects, is computed utilizing the identity matrix (I):

$$T = N \times (I - N)^{-1} \tag{4}$$

4. Step 4: Establishing the Causal Diagram: Based on matrix T, the sum of rows (D) and the sum of columns (R) are calculated:

- Row Sum (D): Indicates the total direct and indirect influence a factor exerts on the overall system (Dispatching power).
- Column Sum (R): Indicates the total influence a factor receives from the overall system (Receiving power).
- From these vectors, two critical indices are formulated:
- Prominence Vector ($D + R$): Represents the overarching importance or degree of interaction of a factor within the system. Higher values signify more significant interaction.
- Relation Vector ($D - R$): Determines the causal power of the factor. If $(D - R) > 0$, the variable acts as a Cause. Conversely, if $(D - R) < 0$, it acts as an Effect.

Finally, a Cartesian coordinate system is constructed where the horizontal axis represents Prominence ($D + R$) and the vertical axis represents Relation ($D - R$). Each factor is plotted as a coordinate point $(D + R, D - R)$, yielding a comprehensive graphical causal diagram of the system.

Results

This section delineates the empirical findings derived from the sequential mixed-methods analysis (Delphi and DEMATEL) conducted on primary data collected from a panel of ten distinguished experts in industrial marketing and the Metaverse ecosystem.

Demographic Characteristics of the Expert Panel

A descriptive analysis of the respondents' demographic profiles underscores the high level of expertise and profound practical experience of the panel members, thereby ensuring the reliability and precision of the subsequent evaluations.

Demographically, 60% of the experts were male, and 40% were female. In terms of academic qualifications, an overwhelming 90% held postgraduate degrees (50% Master's and 40% Doctorate), which guarantees a rigorous academic understanding of the complex subject matter.

Professionally, half of the panel (50%) possessed between 11 and 15 years of operational experience. The detailed demographic distributions are presented in Tables 1 to 3.

Table 1. Frequency Distribution of Respondents by Gender

Gender	Frequency (n)	Percentage (%)
Male	6	60
Female	4	40
Total	10	100

Table 2. Frequency Distribution of Respondents by Educational Level

Educational Level	Frequency (n)	Percentage (%)
Bachelor's Degree (BSc/BA)	1	10
Master's Degree (MSc/MA)	5	50
Doctorate (PhD)	4	40
Total	10	100

Table 3. Frequency Distribution of Respondents by Professional Experience

Professional Experience (Years)	Frequency (n)	Percentage (%)
5 to 10 Years	3	30
11 to 15 Years	5	50
> 16 Years	2	20
Total	10	100

Regarding technological exposure, while fully operational Industrial Metaverse ecosystems are still nascent globally, 80% of the selected experts reported direct managerial involvement in precursor immersive technologies (such as VR training simulators, digital twins of power grids, or smart agriculture IoT dashboards). This ensures their evaluations are firmly grounded in practical digital transformation experiences rather than mere theoretical speculation.

Delphi Method Results: Factor Validation and Screening

Based on the systematic literature review, an initial pool of 25 sub-criteria spanning five primary dimensions (Technological, Economic, Organizational, Social, and Legal/Regulatory) was extracted to evaluate industrial marketing opportunities within the Metaverse.

The empirical results of the Delphi survey indicated that all 25 identified indicators successfully secured a mean score surpassing the predefined validation threshold ($\mu \geq 3.0$). Consequently, the entire set of indicators was corroborated and retained by the expert panel. Notably, the highest consensus and mean scores were attributed to "Hardware Accessibility" ($\mu = 4.1$) and "Digital Media Literacy" ($\mu = 4.1$). The finalized, coded criteria and sub-criteria are systematically cataloged in Table 4.

Table 4. Validated Criteria and Sub-criteria Influencing B2B Marketing Opportunities in the Industrial Metaverse

Primary Dimension (Criteria)	Code	Sub-criteria (Indicators)	Code
Technological Factors	A	ICT Infrastructure	A1
		Hardware Accessibility	A2
		Technological Innovation Capability	A3
		Digital System Integration	A4
		Metaverse Cybersecurity	A5
Economic Factors	B	Metaverse Investments	B1
		Marketing Cost Reduction	B2
		Return on Investment (ROI) in the Metaverse	B3
		Activity Scalability	B4
		Digital Experience-Driven Sales Growth	B5
Organizational Factors	C	Organizational Structure Readiness	C1
		Internal Digital Culture	C2
		Metaverse-Specialized Human Resources	C3
		Digital Change Management	C4
		Top Management Support	C5
Social Factors	D	Customer Technology Adoption	D1
		Digital Media Literacy	D2
		Positive Attitude Towards the Metaverse	D3
		Trust in the Metaverse Platform	D4
		Collaboration Among Industrial Actors	D5
Legal/Regulatory Factors	E	Lack of Explicit Metaverse Legislation	E1
		Data Privacy and Protection	E2
		Digital Intellectual Property Rights	E3
		Compliance with International Regulations	E4
		Transparency in Digital Transactions	E5

Furthermore, to quantitatively verify the degree of consensus among the panel members, Kendall’s Coefficient of Concordance (W) was calculated using SPSS software. For the 10 experts and 25 validated sub-criteria, the analysis yielded a coefficient of $W = 0.784$ ($\chi^2 = 188.16, df = 24, p < 0.001$). According to Schmidt (1997), a W value greater than 0.7 indicates a strong and robust agreement among the experts. Therefore, the statistical output confirms a highly significant consensus, justifying the retention of all 25 sub-criteria for the subsequent DEMATEL analysis.

DEMATEL Analysis Results for Primary Criteria

The DEMATEL method was employed to elucidate the complex cause-and-effect interrelationships among the five primary dimensions. The total relation matrix was calculated to derive the dispatching power (D) and receiving power (R) for each criterion. The ensuing sums ($D + R$) and differences ($D - R$) denote the prominence (overall importance) and relation (net causal effect) of the factors, respectively, as delineated in Table 5.

Table 5. Prominence and Relation of Primary Criteria (DEMATEL)

Dimensions	Code	D	R	$D+R$ (Prominence)	$D-R$ (Relation)
Technological Factors	A	8.939	7.617	16.556	1.322
Economic Factors	B	8.148	6.950	15.098	1.198
Organizational Factors	C	8.933	8.863	17.796	0.071
Social Factors	D	7.872	8.789	16.660	−0.917
Legal/Regulatory Factors	E	6.685	8.359	15.044	−1.673

Based on the empirical coordinates obtained, the primary criteria are categorized into distinct systemic roles:

- Causal Group (Cause Set): Criteria exhibiting positive $D-R$ values operate as the primary drivers of the system. In this network, Technological Factors (A) and Economic Factors (B) fall into the cause set, meaning they exert the highest driving power on other systemic elements. From a strategic perspective, these dimensions must be prioritized by management as the foundational catalysts for Industrial Metaverse integration.

- Effect Group (Effect Set): Criteria exhibiting negative $D-R$ values are classified within the effect set, indicating high susceptibility to the influence of causal variables. Social Factors (D) and Legal/Regulatory Factors (E) belong to this category. Notably, Legal/Regulatory Factors (E), with a $D-R$ score of -1.673, constitutes the most easily influenced (susceptible) criterion within the entire ecosystem.

- Linkage/Intermediary Factors: Organizational Factors (C), possessing a $D-R$ value closely approximating zero (0.071), demonstrate the highest degree of interaction and overall prominence within the network (Maximum $D+R=17.796$). This positions the organizational dimension as a critical intermediary hub bridging the systemic causes and effects.

- Core Relationships: The causal network diagram (Impact-Relations Map) was plotted utilizing a predefined threshold value ($\theta=1.623$) to filter out negligible effects. This threshold was determined scientifically by calculating the sum of the mean (μ) and standard deviation (σ) of all elements within the total-relation matrix (T). According to the topological analysis, Organizational Factors (C) exhibit the highest density of critical interconnections with other criteria, reinforcing its central role in the structural model.

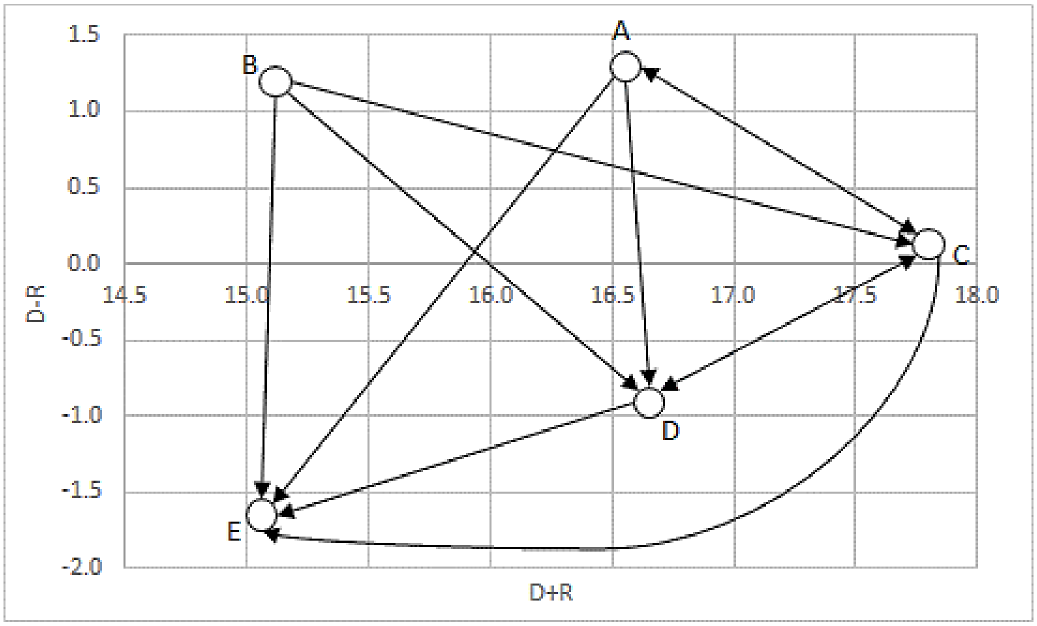

Figure 3. Causal Network Diagram of Primary Criteria

DEMATEL Analysis Results for Sub-criteria

To delineate a more granular architecture of the causal interrelationships within the system, the DEMATEL analytical procedure was systematically extended to the sub-criteria level. This microscopic analysis facilitates the precise identification of localized drivers and dependencies across the 25 indicators.

The computational outcomes, including the dispatching power (D), receiving power (R), prominence ($D + R$), and relation ($D - R$) for each sub-criterion, are detailed in Table 6.

Table 6. Prominence and Relation of Sub-criteria (DEMATEL)

Sub-criterion Name	Code	D	R	$D + R$ (Prominence)	$D - R$ (Relation)
ICT Infrastructure	A1	14.651	14.618	29.270	0.033
Hardware Accessibility	A2	15.611	15.697	31.308	−0.086
Technological Innovation Capability	A3	14.734	15.662	30.396	−0.927
Digital System Integration	A4	15.187	15.301	30.489	−0.114
Metaverse Cybersecurity	A5	16.850	15.858	32.709	0.992
Metaverse Investments	B1	14.817	15.373	30.190	−0.556
Marketing Cost Reduction	B2	14.707	15.169	30.877	−0.462
Return on Investment (ROI) in the Metaverse	B3	15.631	15.190	30.821	0.441
Activity Scalability	B4	15.828	15.375	31.204	0.452
Digital Experience-Driven Sales Growth	B5	16.067	16.053	32.120	0.014
Organizational Structure Readiness	C1	14.836	15.505	30.342	−0.669
Internal Digital Culture	C2	16.905	16.093	33.000	0.812
Metaverse-Specialized Human Resources	C3	15.141	15.693	30.834	−0.551

Sub-criterion Name	Code	D	R	$D+R$ (Prominence)	$D-R$ (Relation)
Digital Change Management	C4	15.462	15.933	31.396	−0.471
Top Management Support	C5	16.551	15.751	32.302	0.800
Customer Technology Adoption	D1	16.026	15.340	31.367	0.685
Digital Media Literacy	D2	15.660	16.460	32.121	−0.801
Positive Attitude Towards the Metaverse	D3	15.868	16.643	32.511	−0.774
Trust in the Metaverse Platform	D4	16.287	16.377	32.664	−0.090
Collaboration Among Industrial Actors	D5	15.951	16.291	32.242	−0.340
Lack of Explicit Metaverse Legislation	E1	16.039	15.545	31.584	0.494
Data Privacy and Protection	E2	16.078	15.389	31.467	0.689
Digital Intellectual Property Rights	E3	14.973	15.735	30.708	−0.761
Compliance with International Regulations	E4	15.099	15.656	30.754	−0.557
Transparency in Digital Transactions	E5	15.084	15.723	30.807	−0.639

Based on the distribution of the net relation values ($D-R$), the sub-criteria are analytically bifurcated into causal (driving) and effect (dependent) clusters:

Causal Sub-criteria (Driving Factors / Base Indicators)

These factors exhibit the highest positive $D-R$ values, signifying their formidable dispatching power and profound systemic influence. They act as the foundational pillars that initiate changes within the B2B marketing ecosystem in the Industrial Metaverse:

- Core Causal Drivers: As demonstrated in the sub-criteria causal map, variables exhibiting positive $D-R$ values constitute the driving force of the system. Notably, the factors spanning technological infrastructure, organizational culture, and regulatory privacy serve as the absolute foundation for initiating Industrial Metaverse adoption in B2B contexts.
- Metaverse Cybersecurity (A5): Exhibits the absolute highest driving power in the network ($D-R=0.992$).
- Internal Digital Culture (C2): Acts as a primary organizational catalyst ($D-R=0.812$).
- Top Management Support (C5): Operates as a critical strategic enabler ($D-R=0.800$).
- Data Privacy and Protection (E2): Functions as a fundamental regulatory driver ($D-R=0.689$).
- Customer Technology Adoption (D1): Represents the core behavioral trigger ($D-R=0.685$).

Effect Sub-criteria (Dependent Factors)

Conversely, these indicators possess the largest negative $D-R$ values, rendering them highly susceptible to fluctuations emanating from the causal variables. Improvements in these areas are contingent upon effectively managing the driving factors:

- Technological Innovation Capability (A3): Emerges as the most dependent sub-criterion in the entire system ($D-R=-0.927$).
- Digital Media Literacy (D2): Highly influenced by broader systemic shifts ($D-R=-0.801$).
- Positive Attitude Towards the Metaverse (D3): Acts as a psychological outcome rather than a trigger ($D-R=-0.774$).
- Digital Intellectual Property Rights (E3): Shows significant susceptibility to preceding legal and technological frameworks ($D-R=-0.761$).
- Organizational Structure Readiness (C1): Functions as a structural outcome heavily reliant on cultural and managerial antecedents ($D-R=-0.669$).

To further unpack the localized dynamics and structural dependencies, specific causal network diagrams were plotted for the sub-criteria within each of the five primary dimensions. This intra-dimensional analysis isolates the internal mechanisms driving each macro-category:

- Organizational Factors (C): Within the localized organizational domain, Top Management Support (C5) functions as the most critical influential driver. It establishes highly significant, outward-directed causal linkages with the rest of the sub-criteria. Conversely, Internal Digital Culture (C2) and Metaverse-Specialized Human Resources (C3) operate as the most susceptible dependent variables. Systemically, this implies that the cultivation of a digital mindset and the acquisition of specialized talent are downstream outcomes that strictly necessitate proactive executive backing and resource allocation.

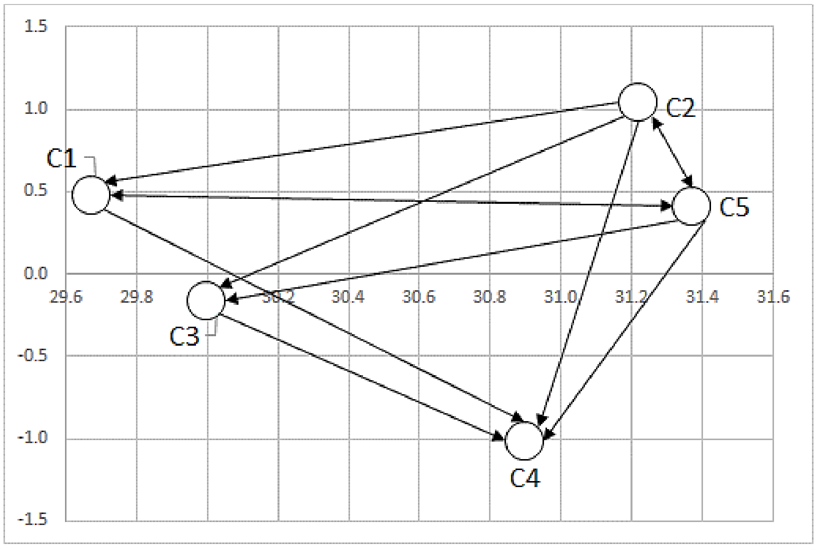

Figure 4. Causal Network Diagram of Organizational Sub-criteria

- Social Factors (D): The topological mapping of the social dimension reveals a distinctly hierarchical structure where Customer Technology Adoption (D1) acts as the absolute baseline driver. It exerts a unilateral, significant influence over all remaining four sub-criteria (D2, D3, D4, D5) while absorbing no meaningful reciprocal impact from them. This structural configuration underscores that prior user readiness and technological acceptance are the non-negotiable prerequisites for building digital trust, media literacy, and positive attitudes toward Industrial Metaverse environments.

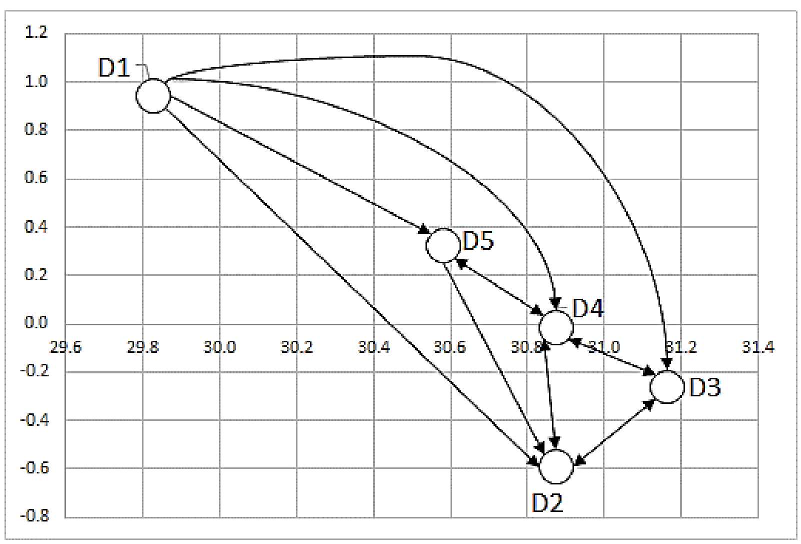

Figure 5. Causal Network Diagram of Social Sub-criteria

- Legal/Regulatory Factors (E): The localized analysis of the legal ecosystem demonstrates that the Lack of Explicit Metaverse Legislation (E1) and the imperative of Data Privacy and Protection (E2) are the most formidable driving forces. These foundational regulatory gaps and privacy concerns act as systemic bottlenecks, fundamentally dictating the trajectory of intellectual property compliance and the transparency of digital transactions.

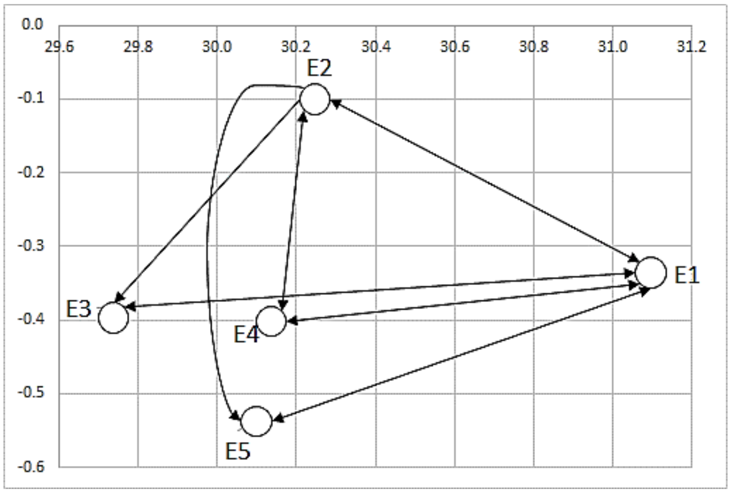

Figure 6. Causal Network Diagram of Legal/Regulatory Sub-criteria

- Technological Factors (A): Within the technological infrastructure sub-network, Metaverse Cybersecurity (A5) decisively stands out as the paramount influential factor. Its superior localized dispatching power highlights a critical technical reality: robust and fail-safe security protocols are an uncompromising prerequisite before systemic integration, hardware accessibility, and overarching technological innovation can be sustainably realized.

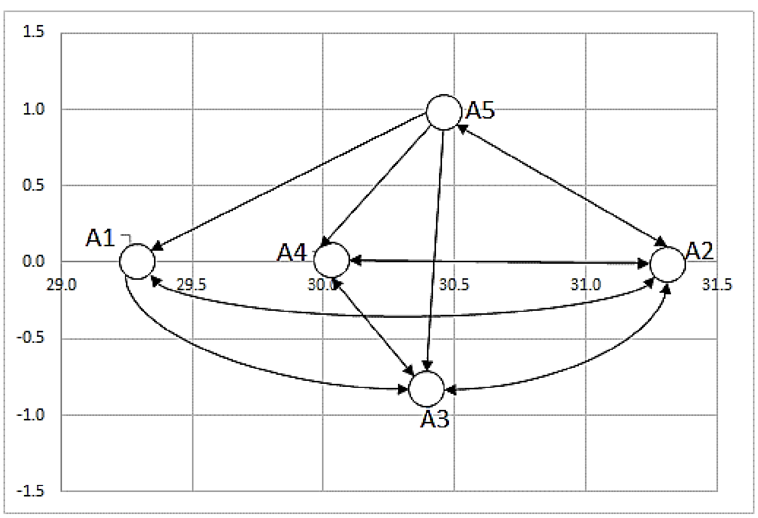

Figure 7. Causal Network Diagram of Technological Sub-criteria.

- Economic Factors (B): Evaluating the internal economic architecture indicates that Activity Scalability (B4) and Return on Investment (ROI) in the Metaverse (B3) are the predominant drivers. From a corporate finance perspective, the strategic capacity to scale operations efficiently and guarantee tangible financial returns fundamentally orchestrates subsequent economic outcomes, including the justification of initial investments and the realization of marketing cost reductions.

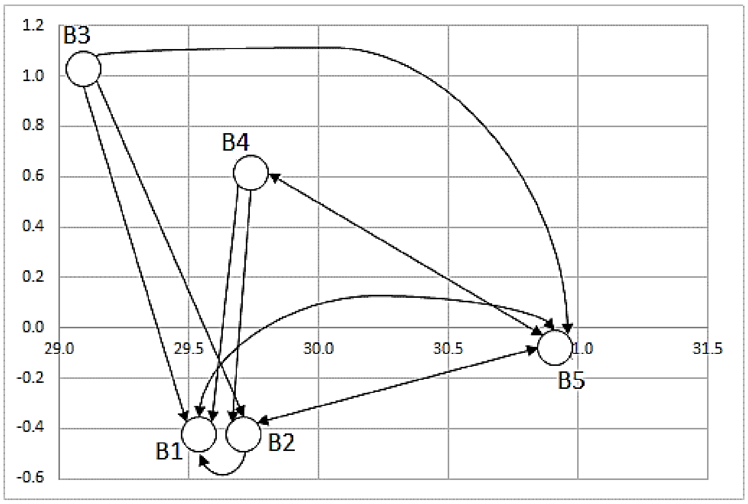

Figure 8. Causal Network Diagram of Economic Sub-criteria

Sensitivity Analysis

To mathematically verify the robustness and stability of the derived causal model, a sensitivity analysis was conducted by adjusting the threshold value (θ) by $\pm 10\%$. Lowering the threshold introduced minor secondary linkages among dependent variables, while raising it filtered out weaker connections. Crucially, under all simulated scenarios, the core causal architecture—specifically the absolute dominance of Organizational Factors (C) as the central hub and the high dispatching power of Metaverse Cybersecurity (A5)—remained strictly stable. This confirms that the empirical findings are highly robust and not overly sensitive to threshold fluctuations.

Discussion

Macro-Level Structural Findings

This research set out to conduct a rigorous network-causal analysis of the factors influencing Business-to-Business (B2B) marketing opportunities within the Industrial Metaverse for Iranian industries. Moving beyond conventional descriptive and correlational paradigms, this study aimed to unearth the complex, multidimensional causal dependencies expected to govern this technological paradigm shift. In the era of digital transformation, the Metaverse emerges as a 3D interactive ecosystem, offering Iranian industries unprecedented capabilities—such as virtual exhibitions, technical simulations, and borderless international sales operations—to transcend geographical and commercial constraints. Utilizing a sequential mixed-methods design (Delphi and DEMATEL), this study successfully validated 25 sub-criteria categorized into five overarching dimensions: Technological, Economic, Organizational, Social, and Legal/Regulatory.

The macro-level DEMATEL structural analysis unequivocally demonstrated that Organizational Factors constitute the most central and highly interactive hub within the entire ecosystem, securing the highest prominence score ($D + R = 17.796$). This systemic centrality dictates that any transformative initiative or capital investment in the Metaverse must originate from the core of the organizational structure; it is heavily contingent upon the internal maturity and readiness of the enterprise. Alongside this centrality, Economic Factors emerged as a fundamental causal driver. By directly permeating the organizational, social, and legal dimensions, economic considerations act as the linchpin for budget allocation, financial risk management, and the overall feasibility of any Metaverse-driven transformation.

Conversely, the Social and Legal/Regulatory Factors exhibited the highest degree of susceptibility (acting as the “Effect Set”). This indicates that stability in user adoption and legal frameworks are downstream outcomes of successful interventions in the technological and economic domains. Specifically, Legal/Regulatory factors recorded the lowest relation score (the most negative $D - R$), highlighting them as the most highly dependent and reactive component in the network.

This macroscopic structure fundamentally distinguishes the B2B Metaverse from its B2C counterpart. While B2C literature heavily emphasizes gamification, consumer brand engagement, and psychological attitudes as primary adoption drivers, this study proves that the Industrial Metaverse is strictly driven by functional utility, systemic readiness, and risk mitigation. For instance, 'Positive Attitude' (D3) emerged merely as a highly dependent outcome (effect set) in the B2B model, completely subordinated to overarching economic and security imperatives.

Micro-Level Causal Dynamics

Drilling down to the sub-criteria level provided high-resolution insights into the exact nodes of influence. Metaverse Cybersecurity (A5) exhibited the absolute highest dispatching power ($D - R = +0.992$). This critical finding illustrates that within the currently volatile technological landscape of Iran, robust cybersecurity is not merely an IT concern; it is a vital systemic prerequisite for establishing B2B transactional trust, effectively acting as the Achilles' heel of the entire network.

Within the organizational domain, Internal Digital Culture (C2, $D - R = +0.812$) and Top Management Support (C5, $D - R = +0.800$) were identified as the most potent causal drivers. Systemically, these components must be the primary targets for managerial interventions. Enhancing executive backing and cultivating a digital mindset will organically trigger downstream improvements in multiple dependent variables, such as Technological Innovation Capability and Digital Change Management.

Consequently, highly dependent variables (such as structural readiness or change management) should not be the initial starting points for capital investment. Rather, they should be viewed as the natural, self-optimizing outcomes of successful prior interventions in the foundational causal drivers.

It is crucial to contextualize these findings specifically within the mechanisms of B2B marketing, distinguishing them from generic digital transformation initiatives. While factors like Cybersecurity (A5) and Data Privacy (E2) are ubiquitous IT concerns, their prominent causal role in this model stems from the unique nature of industrial transactions. In the Industrial Metaverse, cybersecurity is not merely about protecting consumer payment data; it involves securing highly sensitive intellectual property, proprietary 3D digital twins of manufacturing plants, and integrated supply chain architectures. A breach here compromises the entire inter-organizational ecosystem.

Similarly, the strong driving power of Internal Digital Culture (C2) and Top Management Support (C5) is uniquely tied to the complexity of the B2B buying center. Unlike B2C marketing, which targets individual consumers, B2B sales cycles require coordinated efforts across multiple departments (engineering, procurement, sales) to engage clients in virtual environments. Therefore, fostering long-term relational trust and generating B2B leads within virtual reality fundamentally demands a unified, top-down cultural shift rather than isolated departmental marketing tactics.

Conclusion

The findings of this research strongly resonate with both domestic and international literature while offering a superior structural model that transcends previous correlational boundaries. Domestically, the results align with the systematic evaluations by Buhalis et al. (2023), who emphasized the critical role of communication infrastructures, technology, and economic security. Their assertion regarding the paramount importance of information security perfectly corroborates the high causal influence of Cybersecurity (A5) identified in the present study.

On an international scale, this research corroborates the recent theoretical paradigms proposed by Deleuze (2024) and Vangi et al. (2024), which explicitly explore B2B opportunities in the Metaverse. While these global studies highlight the advantages of digital interactions, enhanced efficiency, and mixed-reality capabilities, the present research adds a crucial caveat: these capabilities are strictly subordinated to organizational and economic infrastructures. Furthermore, their emphasis on the necessity of trust, data protection, and legal frameworks aligns flawlessly with the high susceptibility of Social and Legal factors found in the model, validating the urgent need for responsive legislation.

Ultimately, the fundamental theoretical contribution of this study lies in its methodological execution. While prior studies merely established the existence of relationships, the application of DEMATEL here delineates the direction and intensity of causal permeation, providing a robust, evidence-based foundation for strategic prioritization.

Finally, this study refines the epistemological boundaries of current Metaverse research. By utilizing DEMATEL, this research does not claim to capture the ex-post empirical adoption dynamics or longitudinal market behaviors, which are currently unobservable given the nascent state of the Industrial Metaverse (Cui & Wang, 2023). Rather, it captures and quantifies the ex-ante cognitive maps and mental models of senior industry experts (Pinto et al., 2023). Mapping these expert beliefs is fundamentally critical; in B2B contexts, it is precisely these perceived causalities and strategic anticipations that dictate initial resource allocation and pilot investments. Thus, this study translates abstract technological hype into a structured cognitive baseline, paving the way for future empirical studies to test these anticipated relationships against real-world adoption data.

Managerial and Practical Implications

The findings of this causal network analysis offer a strictly prioritized roadmap for B2B executives, shifting the focus from technological hype to targeted, evidence-based interventions. The recommendations are directly derived from the systemic roles (Cause vs. Effect) and the dispatching power ($D - R$) of the analyzed sub-criteria:

- Establishing Zero-Trust Cybersecurity for IP Protection (Derived from A5, apex driver): Because Metaverse Cybersecurity ($D - R = +0.992$) emerged as the absolute highest driving force, managers must realize that the B2B Metaverse is unviable without it. In industrial settings, the risk is not merely financial fraud, but the exposure of proprietary 3D digital twins and trade secrets. Therefore, before investing in VR hardware or digital showrooms, B2B organizations must mandate zero-trust security architectures and blockchain-enabled data verification to ensure partner trust in virtual environments.

- Forming Cross-Functional Metaverse Task Forces (Derived from C2 and C5, core levers): The prominent causal power of Top Management Support ($D - R = +0.800$) and Internal Digital Culture ($D - R = +0.812$) indicates that Metaverse integration cannot be siloed within the IT department. Executives must form cross-functional task forces (comprising sales, engineering, and procurement) to foster a unified digital mindset. Cultivating this internal readiness is a systemic prerequisite that will organically resolve downstream friction in change management and technological capability.
- Aligning Virtual Investments with Strict B2B ROI Metrics (Derived from B3 and B4, foundational catalysts): Economic viability fundamentally drives the system. Instead of adopting the Metaverse for brand novelty (as seen in B2C), B2B managers should initially deploy Metaverse tools only in high-impact, scalable areas—such as virtual product prototyping or remote technical maintenance—where tangible Return on Investment (ROI) and cost reduction can be transparently measured and presented to the board of directors.
- Taking a Monitoring Stance on Legal and Social Variables (Derived from the Effect Set): Given the high susceptibility of Social and Legal factors (e.g., Lack of Explicit Legislation, $D - R = -1.673$), individual firms should not dissipate initial capital trying to proactively solve these macro-level issues. Instead, B2B enterprises should take a monitoring and lobbying stance. They must focus on solidifying their internal technological and organizational capabilities (the Cause variables) while collaborating with industry consortia to reactively navigate regulatory frameworks as they mature.

Limitations and Directions for Future Research

While this study offers robust structural insights, it acknowledges certain limitations. First, the sample size ($n = 10$), although scientifically justified for MCDM techniques like DEMATEL, relies inherently on subjective expert judgments. Second, and more importantly, the expert panel was drawn exclusively from macro-industrial, public infrastructure sectors. Given that the dynamics of private SMEs, manufacturers, and independent distributors might differ, there is an inherent sampling limitation. Consequently, future researchers are strongly encouraged to test and validate this framework within private industrial sectors to enhance the generalizability of the findings.

For future research, it is highly recommended to employ a hybrid DEMATEL-ANP (DANP) approach to accurately extract the inner-dependency weights of the criteria. Furthermore, integrating DEMATEL with Interpretive Structural Modeling (ISM) could yield a more comprehensive, multi-level hierarchical model. Ultimately, translating these findings into hypotheses and testing them on a large-scale industrial population using Variance-based Structural

Equation Modeling (e.g., PLS-SEM) will significantly enhance the empirical generalizability of the results.

Author Contributions

All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

Data Availability Statement

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Ethical considerations

The authors avoided data fabrication, falsification, and plagiarism, and any form of misconduct.

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Conflict of interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-assisted technologies in the writing process

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