Ranking the Factors Influencing the Resilient Supply Chain in Mobarakeh Steel Company

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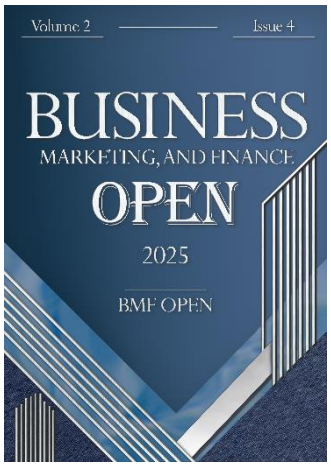

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Abstract: This study aimed to identify and prioritize the key factors influencing supply chain resilience in Mobarakeh Steel Company using expert-based analysis and structural modeling techniques. An exploratory research design was adopted, beginning with the application of the Delphi method to gather and refine expert opinions from 18 specialists in the steel industry and academia. Semi-structured interviews were conducted to screen resilience factors, and less significant variables were eliminated across multiple rounds. Following this, a structured questionnaire based on the refined factors was distributed among 300 participants, selected through simple random sampling from a population of 850 managers and supervisors. A total of 280 completed questionnaires were collected. Data were analyzed using descriptive statistics and Structural Equation Modeling (SEM) through SmartPLS software to rank and validate the influencing factors. The analysis revealed that transformational leadership in the supply chain was the most influential factor, followed by resource-based dynamic capabilities, the utilization of digital tools, management of partner dissatisfaction, and customer relationship quality. Other significant but relatively lower-ranking factors included communication quality, supply chain flexibility, and supply chain robustness. Meanwhile, environmental dynamism showed a negative and minimal effect. The results emphasized the crucial role of leadership, digitalization, relational management, and dynamic capabilities in building a resilient supply chain within the steel industry context. The findings highlight that a multifaceted approach combining strong leadership, technological advancement, robust relational networks, and dynamic internal capabilities is essential for enhancing supply chain resilience. Mobarakeh Steel Company, and similar organizations, must prioritize leadership development, digital integration, relationship strengthening, and dynamic capability building to effectively navigate supply chain disruptions and achieve sustainable operational continuity.

Keywords: Supply Chain Resilience, Transformational Leadership, Digital Tools, Dynamic Capabilities, Steel Industry

1. Introduction

In today's volatile and unpredictable global environment, supply chain resilience has become a critical priority for industries seeking to maintain competitive advantage and operational continuity. Particularly in sectors characterized by complexity and high interdependency, such as the steel industry, developing a resilient supply chain is fundamental for mitigating disruptions and ensuring sustainable performance. Recent studies underscore the necessity of resilience strategies to cope with uncertainties, ranging from geopolitical tensions to technological disruptions and pandemics [1, 2]. Mobarakeh Steel Company, as one of the largest and most influential steel

producers in the Middle East, faces a wide array of supply chain vulnerabilities that necessitate strategic and systematic evaluation of resilience-enhancing factors.

Supply chain resilience is defined as the adaptive capability of a supply chain to prepare for, respond to, and recover from disruptions while maintaining continuity of operations at an acceptable level [3]. The concept has evolved beyond mere risk management, encompassing proactive capabilities such as flexibility, collaboration, and innovation [4, 5]. Several scholars have emphasized that resilience requires an integrated approach, combining technological advancement, relational coordination, and dynamic capabilities [6, 7]. In particular, the role of digital transformation has attracted significant attention as it empowers organizations to enhance visibility, agility, and decision-making across the supply network [6, 8].

Research indicates that digital tools are pivotal in enabling resilient supply chains by enhancing real-time information flow, predictive analytics, and supply chain visibility [9, 10]. Mobarakeh Steel Company, operating in a highly competitive and dynamic market, must leverage such digital capabilities to anticipate disruptions and respond effectively. Furthermore, the development of dynamic capabilities—such as resource reconfiguration and knowledge management—has been shown to significantly influence supply chain resilience [11, 12]. These capabilities allow firms to adapt to environmental changes and sustain operational performance under duress [13].

Relational factors such as supplier and customer integration also contribute significantly to supply chain resilience [14, 15]. Close collaboration with suppliers enhances flexibility and responsiveness, while strong customer relationships ensure market stability and information sharing during disruptions [16]. Moreover, effective communication quality across the supply chain network plays a fundamental role in synchronizing responses and coordinating recovery efforts [2, 17].

Empirical research in various industries has identified multiple antecedents of supply chain resilience, including transformational leadership, environmental dynamism, and supply chain integration [18-20]. For example, transformational leadership styles that inspire innovation and adaptive thinking have been associated with enhanced organizational resilience [18]. Similarly, digital marketing orientation and supply chain reciprocity have been highlighted as emerging drivers of resilience in contemporary supply chains [5, 21].

In the specific context of the steel industry, resilience becomes even more critical due to the sector's exposure to supply fluctuations, geopolitical risks, and market demand variability [22, 23]. Studies have shown that steel manufacturers must prioritize both operational and strategic factors to ensure supply continuity and customer satisfaction [24, 25]. In this regard, the alignment of dynamic capabilities with digitalization strategies offers a promising pathway for building a resilient and agile supply chain [19, 26].

Building on these theoretical foundations, the present study aims to identify and rank the factors influencing supply chain resilience in Mobarakeh Steel Company. This effort is crucial because although numerous factors have been proposed in the literature, their relative importance and practical applicability in the steel industry context remain underexplored. Using a combination of Delphi method and structural equation modeling, this study systematically evaluates expert opinions to construct a prioritized model of resilience factors.

The importance of employing a structured methodology such as the Delphi technique lies in its capacity to consolidate expert judgment in conditions of uncertainty, reducing bias and enhancing reliability [15, 20]. In addition, structural equation modeling enables the analysis of complex interrelationships among variables and provides robust insights into the causal pathways shaping supply chain resilience [10, 12]. This approach ensures that the findings of the study are both theoretically grounded and practically relevant.

Among the key variables examined in this study are digital tools, supplier relationship, customer relationship, supply chain robustness, flexibility, digital marketing orientation, reciprocity, transformational leadership, information processing capabilities, and dynamic capabilities based on resources and knowledge. Additionally, factors such as partner dissatisfaction, environmental dynamism, communication quality, and supply chain integration are evaluated to provide a comprehensive perspective on resilience-building mechanisms [1, 7, 11].

Previous research has underscored that reliance solely on technological solutions is insufficient without the accompanying development of relational and organizational capabilities [2, 9]. Effective resilience strategies demand the simultaneous enhancement of technical systems, human competencies, and structural arrangements [17, 27]. Therefore, a holistic approach that integrates digital transformation, leadership, relationship management, and dynamic capabilities is necessary for achieving supply chain resilience [3, 4].

The dynamic and disruptive nature of the external environment, particularly evident in the wake of events such as the COVID-19 pandemic and global trade disruptions, has further amplified the urgency of embedding resilience into supply chains [25, 28]. Companies that invested in resilience-enhancing practices before the pandemic were better able to sustain their operations and recover faster [5, 14]. Accordingly, the steel industry, with its critical role in infrastructure and manufacturing, must develop robust, flexible, and adaptive supply chain strategies to secure its position in an increasingly competitive and uncertain market [22, 29].

In conclusion, this study addresses an important gap in the existing literature by providing a contextualized analysis of the factors influencing supply chain resilience within the steel industry, using Mobarakeh Steel Company as a case study.

2. Methodology

The present study employed an exploratory research design aimed at identifying and classifying correlated groups among various variables related to the resilience of the supply chain in Mobarakeh Steel Company. To develop the model components, the Delphi method was utilized. The Delphi technique is a structured and systematic communication process that facilitates group decision-making among academic and steel industry experts, particularly under uncertain conditions where minimizing error is critical. Unlike traditional survey methods, the validity of the Delphi method lies not in the number of participants but in the academic and professional credibility of the experts involved. Therefore, the selection of highly knowledgeable and experienced experts was given utmost importance. In this study, eighteen experts from academia and the steel industry, all with specialized knowledge related to the research subject, were selected. Following the identification of these experts, interviews were conducted to screen and refine factors impacting supply chain resilience, with less influential factors gradually eliminated across several stages. Subsequently, the results were analyzed using Structural Equation Modeling (SEM) with SmartPLS software to extract the key indicators forming the resilience model based on expert opinions. The second phase of the research involved determining the intensity of the relationships among model components and indicators by applying SEM concepts to the data obtained from previous steps, leading to the development of a conceptual model of factors affecting supply chain resilience. Given the qualitative orientation of the initial phase, the statistical population included individuals with sufficient expertise and familiarity with the topic, namely, university academics and steel industry specialists. The sampling approach adopted was theoretical sampling, often referred to as purposive sampling, where selection is based on participants' knowledge and relevance to the research topic rather than randomness. In this study, the snowball sampling technique was employed, beginning with an initial expert interview, after which participants were asked to introduce other

knowledgeable individuals. This process continued until theoretical saturation was reached, concluding with eighteen interviews.

The data collection tools for this research included structured questionnaires and semi-structured interviews. For the qualitative phase, after reviewing theoretical foundations, semi-structured interviews were initiated with university and industry experts. This format allowed the researcher to gather specific information while maintaining flexibility for in-depth exploration as needed. Although the core structure of the interview questions remained consistent, probing questions were asked when necessary to enrich the data collected. Interviewing continued until data saturation was achieved, ensuring a comprehensive understanding of the factors influencing supply chain resilience. For the quantitative phase, a standardized questionnaire was used to quantify expert opinions on predefined criteria and indicators. The questionnaire employed a five-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree," assigning values of 5 to 1, respectively. This design enabled the conversion of qualitative judgments into quantitative data for subsequent statistical analysis. The questionnaire was distributed among a sample of 300 participants drawn from a total population of 850 managers, supervisors, and experts in Mobarakeh Steel Company and related academic fields. Ultimately, 280 completed questionnaires were collected. Simple random sampling was employed to select participants for the quantitative phase, ensuring representativeness across different organizational levels and expertise domains.

Data analysis was conducted in multiple stages, beginning with the categorization and entry of questionnaire responses into Microsoft Excel. The data were then imported into SmartPLS software for comprehensive analysis using both descriptive and inferential statistical methods. In the qualitative phase, after initial coding and extraction of key indicators through expert interviews, the semi-structured data were systematically compared across interviews to identify recurring themes and consensus points. For the quantitative analysis, descriptive statistics such as means and standard deviations were computed to provide an overview of the data distribution. Inferential techniques, primarily Structural Equation Modeling, were then employed to test the relationships among variables and validate the conceptual model of supply chain resilience factors. Throughout the analysis, careful attention was paid to ensuring the robustness and reliability of findings, thereby contributing to the validity and practical applicability of the resulting model for enhancing resilience in supply chain operations at Mobarakeh Steel Company.

3. Findings and Results

In the qualitative phase of the study, interviews were conducted with a total of 18 experts from the academic and steel industry sectors. Of these participants, 15 were male and 3 were female. Regarding educational background, 6 individuals had specialized in finance, while 12 had a background in management. In terms of academic qualifications, 11 participants held master's degrees and 7 held doctoral degrees. As for work experience, 6 participants had between 15 and 20 years of professional experience, 8 participants had between 21 and 25 years of experience, and 4 participants had more than 25 years of experience in fields related to the resilience of supply chains.

In the quantitative phase of the study, data were collected from 280 respondents. In terms of age distribution, the majority of participants (42.5 percent) were between 30 and 40 years old, while 34.3 percent were in the 40 to 50 age group, 17.7 percent were older than 50 years, and only 5.5 percent were younger than 30 years. Regarding educational attainment, most respondents (55.7 percent) held a master's degree, followed by 24.3 percent who held a bachelor's degree and 20 percent who had earned a doctoral degree. Concerning work experience within the

organization, 41.4 percent of the participants reported having between 11 and 15 years of service, 26.4 percent had more than 15 years of experience, 25 percent had between 5 and 10 years of experience, and a smaller portion, 7.1 percent, had less than 5 years of service.

Based on the results obtained from the Delphi method and subsequent structural equation modeling analysis, the factors influencing supply chain resilience were identified and ranked according to their standardized coefficients.

Table 1. Descriptive Statistics of Research Variables

Variables	Mean	Median	Standard Deviation	Minimum	Maximum
Company Financial Performance	4.12	3.43	0.63	1	7
Supply Chain Resilience	4.09	3.75	0.64	1	5
Digital Tools	3.98	3.20	0.70	1	5
Supplier Relationship	4.02	3.60	0.71	1	5
Customer Relationship	4.12	3.80	0.64	1	5
Supply Chain Robustness	4.09	4.00	0.64	1	5
Supply Chain Flexibility	4.08	4.20	0.65	1	5
Digital Marketing Orientation	4.09	4.20	0.63	1	5
Supply Chain Reciprocity	4.08	4.20	0.65	1	5
Transformational Leadership in Supply Chain	4.09	4.20	0.63	1	5
Information Processing Capability	4.14	4.00	0.61	1	5
Knowledge-Based Dynamic Capability	4.13	4.20	0.62	1	5
Resource-Based Dynamic Capability	4.09	4.20	0.64	1	5
Partner Dissatisfaction	4.08	4.00	0.63	1	5
Environmental Dynamism	4.06	4.20	0.60	1	5
Communication Quality	4.04	4.20	0.63	1	5
Supply Chain Integration	4.04	4.20	0.65	1	5

The descriptive findings reveal that the central tendency indicators, particularly the mean, provide insights into the equilibrium point and central focus of the distribution of responses. For instance, the mean value for the variable of supply chain resilience is 4.09 on a scale from 1 to 5, indicating that, on average, respondents rated the resilience of the supply chain above the mid-level. The median for this variable stands at 3.75, suggesting that half of the respondents provided ratings below this value and the other half above it. Across all variables, the means generally cluster around values slightly above 4.00, reflecting a positive evaluation of factors such as supplier and customer relationships, supply chain robustness, digital tool adoption, and dynamic capabilities. The standard deviations for most variables hover around 0.6 to 0.7, indicating a moderate spread of responses around the mean. Minimum and maximum values across variables confirm that the full range of the scale was utilized, with responses varying between the lowest value of 1 and the highest values of 5 or, for company financial performance, up to 7. These descriptive statistics collectively suggest that participants generally perceived a favorable status across key dimensions affecting the resilient supply chain at Mobarakeh Steel Company.

Table 2. Factors Influencing Supply Chain Resilience

No.	Components	Coefficient	Rank
1	Digital Tools	0.489	3
2	Supplier Relationship	0.354	9
3	Customer Relationship	0.420	5
4	Supply Chain Robustness	0.358	8
5	Supply Chain Flexibility	0.367	7
6	Digital Marketing Orientation	0.160	11
7	Supply Chain Reciprocity	0.142	12
8	Transformational Leadership in Supply Chain	0.757	1
9	Information Processing Capability	0.322	10
10	Knowledge-Based Dynamic Capability	0.127	13
11	Resource-Based Dynamic Capability	0.524	2
12	Partner Dissatisfaction	0.455	4
13	Environmental Dynamism	-0.082	15
14	Communication Quality	0.393	6
15	Supply Chain Integration	0.110	14

As shown in Table 2, the most influential factor was transformational leadership in the supply chain, with a coefficient of 0.757, followed by resource-based dynamic capability at 0.524 and the utilization of digital tools at 0.489. Partner dissatisfaction was the fourth most influential factor with a coefficient of 0.455, and customer relationship ranked fifth at 0.420. Other significant factors included communication quality (0.393), supply chain flexibility (0.367), supply chain robustness (0.358), and supplier relationship (0.354). In contrast, factors such as digital marketing orientation (0.160), supply chain reciprocity (0.142), knowledge-based dynamic capability (0.127), and supply chain integration (0.110) had relatively lower impacts. Notably, environmental dynamism displayed a negative and negligible effect with a coefficient of -0.082, indicating that external environmental fluctuations did not significantly contribute to enhancing the resilience of the supply chain in this context. The visual model illustrating these relationships is presented in Figure 1.

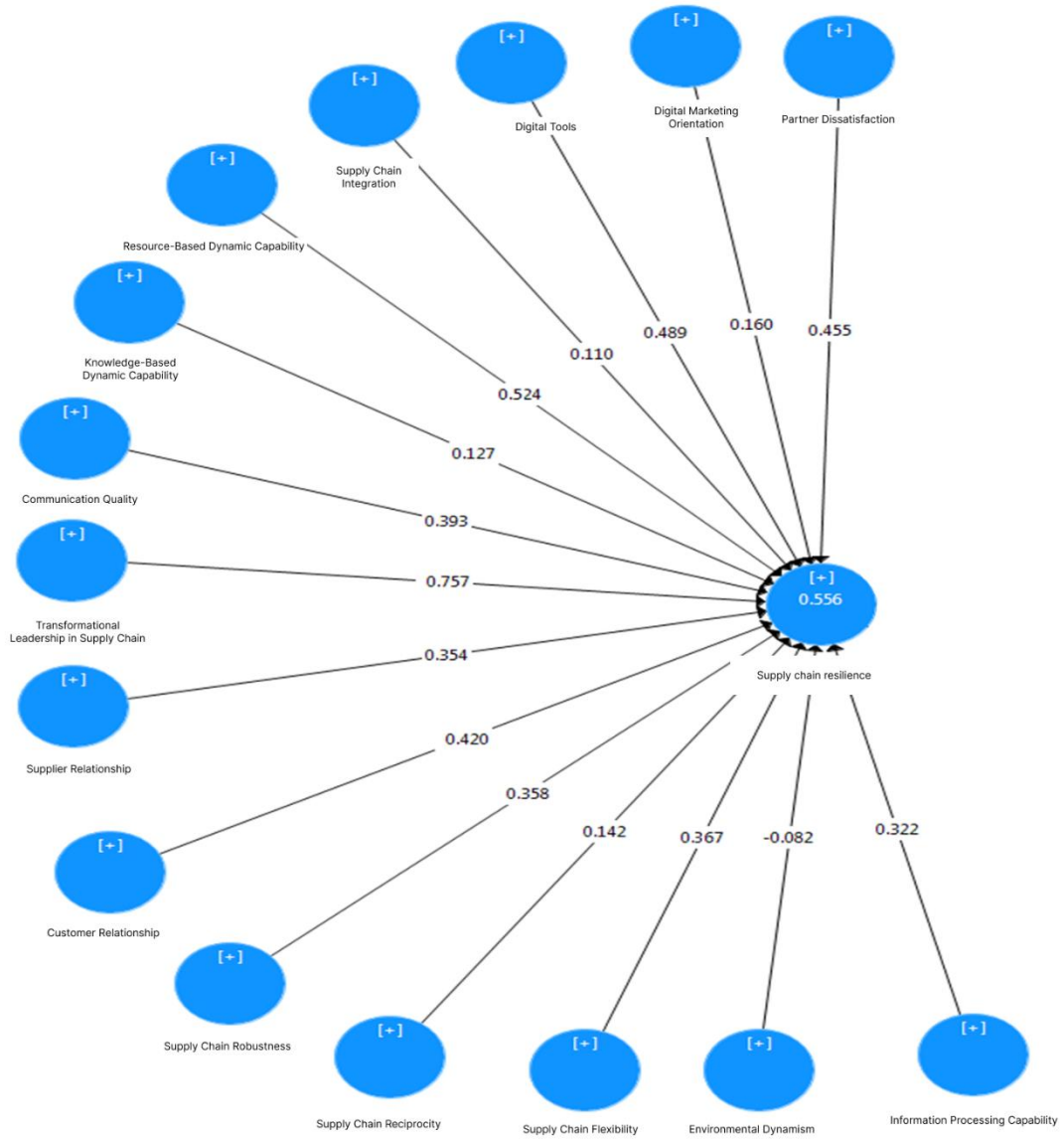

Figure 1. Final Model of the Study

4. Discussion and Conclusion

The primary objective of this study was to identify and rank the factors influencing supply chain resilience in Mobarakeh Steel Company. The results indicated that transformational leadership in the supply chain held the highest influence on resilience, followed by resource-based dynamic capability, the use of digital tools, partner dissatisfaction management, and customer relationship strength. Other factors such as communication quality, supply chain flexibility, and supply chain robustness also demonstrated notable impacts, whereas environmental dynamism had a negative and relatively insignificant effect.

Transformational leadership emerged as the most influential factor, highlighting the critical role of visionary, adaptive, and motivational leadership in strengthening supply chain resilience. Leaders who foster innovation, collaboration, and proactive change management are instrumental in enabling supply chains to anticipate disruptions and respond effectively [18]. This result is strongly aligned with the findings of Pu et al., who emphasized that leadership capabilities significantly enhance a firm's dynamic and relational responses to crises

[4]. Similarly, Karaoulanis also asserted that survival strategies in turbulent times heavily depend on transformational leadership that can steer organizations through uncertainty [3].

The second most critical factor was identified as the resource-based dynamic capability. Organizations that can effectively reconfigure and mobilize internal and external resources exhibit superior resilience during disruptions [11]. This finding resonates with Jiang et al., who concluded that supply chains with strong resource capabilities could better manage risks and sustain operations [13]. Yuan's research further supported this view, highlighting that configurations of multiple institutional and resource capabilities contribute significantly to building resilient supply networks [12].

Digital tools ranked third, underlining the vital importance of digitalization in modern supply chain resilience. Digital technologies facilitate real-time monitoring, predictive analytics, and enhanced decision-making, allowing organizations to detect disruptions earlier and coordinate responses more efficiently [6]. This result echoes the work of Wang et al., who demonstrated that digital empowerment mechanisms positively affect innovation vitality and supply chain resilience [8]. Similarly, Ismail et al. emphasized that smart supply chains enabled by digital tools substantially improve operational performance and resilience outcomes [9].

Interestingly, partner dissatisfaction was the fourth most influential factor, suggesting that negative relational dynamics significantly undermine supply chain stability. Managing dissatisfaction through transparent communication, trust-building, and fair conflict resolution is essential to prevent disruptions caused by strained relationships [14]. Prior studies have similarly indicated that unresolved partner grievances can escalate supply chain vulnerabilities [1]. Fang and Wang also stressed the importance of strong relational ties in agricultural supply chains to buffer against external shocks [17].

Customer relationship quality was another prominent factor, confirming that supply chain resilience is not solely a matter of upstream supplier management but also involves downstream customer engagement. Effective customer relationships enhance demand visibility and facilitate rapid adaptation to market changes [15, 16]. This aligns with findings by Yao, who pointed out that resilient supply chains are characterized by tight customer feedback loops and collaborative adjustment processes [21].

Communication quality also showed a notable positive effect, reinforcing the assertion that high-quality, timely, and accurate information exchange is a cornerstone of supply chain resilience [2]. Research by Lin et al. further confirmed that effective communication strengthens the synchronization of supply chain responses and supports better crisis management [10].

Supply chain flexibility and robustness were moderately influential, which is consistent with previous studies highlighting these as traditional foundations of resilience [5]. Supply chains that are flexible can reroute logistics, adjust procurement strategies, and reconfigure production lines in response to disruptions, while robust supply chains possess inherent redundancies and structural strength to withstand external shocks [25, 27].

Other factors, such as digital marketing orientation, supply chain reciprocity, and knowledge-based dynamic capabilities, demonstrated relatively lower coefficients. While these elements contribute to overall resilience, their influence appears less direct or potent compared to leadership and digitalization factors. Jing et al. similarly found that knowledge-based dynamic capabilities, while valuable, require strong complementary structures to manifest resilience outcomes [20].

Supply chain integration showed one of the lowest impacts in this study. Although integration is widely discussed as a resilience enhancer, this result suggests that in the case of Mobarakeh Steel Company, integration efforts may not yet be fully matured or effective in building resilience [13, 30]. Sunmola et al. warned that without

sufficient depth and trust, integration initiatives could remain superficial, offering limited protection against disruptions [2].

Finally, environmental dynamism had a negative and minimal influence, indicating that frequent external changes—while challenging—did not directly contribute to resilience and might even hinder it if not managed properly. This is consistent with findings from Wan et al., who found that high volatility in the external environment complicates resilience efforts unless organizations are equipped with robust internal mechanisms [14].

Overall, the study's findings align closely with contemporary supply chain resilience literature, confirming that a multi-faceted strategy involving leadership, digitalization, relationship management, and dynamic capabilities is essential for achieving sustainable resilience [3, 6, 17, 19].

While this study provides valuable insights into the factors influencing supply chain resilience in Mobarakeh Steel Company, it is not without limitations. First, the research relied on the Delphi method combined with expert judgment, which, while robust for exploratory studies, may introduce subjectivity despite efforts to mitigate it. Second, the study's sample was drawn exclusively from the steel industry in Iran, limiting the generalizability of findings to other industries or regions. Third, the research adopted a cross-sectional design, capturing insights at a single point in time, which may not reflect evolving dynamics in the supply chain environment. Fourth, although the study integrated structural equation modeling for validation, potential biases inherent in self-reported data from interviews and questionnaires remain a constraint. Lastly, some emerging technological or environmental factors may not have been fully captured, considering the rapid pace of change in digitalization and global supply chain trends.

Future research should aim to expand the scope by including multiple industries to validate whether the identified factors hold similar importance across different supply chain contexts. Longitudinal studies tracking changes in resilience capabilities over time would also be highly valuable in capturing dynamic evolutions rather than static snapshots. Furthermore, incorporating quantitative measures of actual supply chain performance during disruptions could strengthen the objectivity of findings. Comparative studies between industries heavily reliant on upstream supply networks, such as steel, and those oriented toward service delivery, such as logistics or healthcare, would provide deeper insights into context-specific resilience strategies. Exploring the moderating role of environmental turbulence, digital maturity, and organizational culture could also offer richer explanatory power for resilience outcomes.

Based on the results of this study, several practical recommendations can be made for Mobarakeh Steel Company and similar organizations. First, investment in leadership development programs that cultivate transformational leadership skills among supply chain managers should be prioritized. Second, adopting and expanding digital tool usage for supply chain monitoring, forecasting, and coordination must be considered a strategic necessity rather than an optional enhancement. Third, fostering stronger relational bonds with both suppliers and customers through transparent communication and mutual trust initiatives can significantly enhance resilience. Fourth, organizations should systematically build and maintain dynamic capabilities, particularly focusing on the flexible reconfiguration of resources and processes in response to emerging threats. Finally, internal mechanisms for managing dissatisfaction among partners should be institutionalized to preempt relational breakdowns that could compromise supply chain stability.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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