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Research Article

Examining the role of world-class manufacturing on supply chain resilience in the steel industry

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ABSTRACT

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Abstract:

A resilient supply chain is an adaptive capability of a supply chain to reduce the likelihood of encountering sudden disruptions, resist the spread of disruptions by maintaining control over structures and performance, and recover, repair, and respond with an immediate and effective response plan to prevent disruption and restore the supply chain to a resilient operational state. Determining the factors of supply chain resilience and prioritizing and determining their effects in the program horizon are management necessities in the steel industry. Because this chain faces diverse situations and characteristics such as: uncertainty and certainty in supply conditions, demand, competitive pressure, complexity and technological change. The purpose of the research is to investigate the role of world-class production on supply chain resilience by considering the mediating role of market orientation. The research method is applied in terms of purpose and descriptive survey in terms of method. The statistical population is experts in the field of supply chain and world-class production who have experience in the steel industry. Data processing and analysis were used using factor analysis and structural equations. The results showed that world-class production has an effect on supply chain resilience. The mediating role of market orientation in the relationship between world-class production and supply chain resilience was also confirmed. Finally, practical suggestions were presented.

Keywords:
Resilience, World-Class Manufacturing, Supply Chain, Steel Industry

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1. Introduction

The concept of resilient supply chain, which has been developed theoretically and without field studies, has remained mostly in the theoretical stage and has not been further investigated in the field. For this reason, while emphasizing that this concept is in the early stages of formation and has much room for expansion and change, researchers have identified other dimensions of the resilient supply chain structure with a pragmatic world-class approach and expanded it and presented a comprehensive model of resilient supply chain by considering different theories and expanding the research horizon by including political, economic, cultural and demographic variables. Therefore, with the above mentioned issues, there seems to be a theoretical gap in the field of resilient supply chain. (Bashiri et al, 2025: 11-23).

Another noteworthy point is the lack of responsiveness of world-class automotive parts manufacturing in bad economic conditions. In many organizations, partners at the chain level still operate independently, and planning and control are carried out separately at the chain level, and each partner pursues separate goals. This prevents information about environmental changes that require rapid response from being transmitted at the chain level. (Huang et al, 2023: 20-32).

In a situation where the recession in the market has caused great harm to the Iranian consumer and has faced the society with economic, cultural and political crises, supply chain management chooses the supply chain resilience approach to increase the effectiveness of companies, as well as improve competitiveness and the ability to prevent and overcome various disruptions, increase flexibility and develop the ability of the supply chain to respond quickly to changes in customer demand and higher quality and their competitiveness in reducing costs and reducing delivery time and increasing the level of customer service. This highlights the need to study the dimensions of a resilient supply chain, its consequences and antecedents in order to encourage producers in such circumstances. (Eggert & Hartmann , 2023).

Key Components of World-Class Manufacturing

- Reduced Waiting Time: Reduced delivery or waiting time is based on the premise that faster delivery positively impacts customer satisfaction and purchase intention, ultimately leading to higher sales. Reduced waiting time has been shown to significantly increase the likelihood of repeat business, especially among new customers (Bakhtiari,2023)
- Reduced Operating Costs: Reducing operating costs in manufacturing systems can lead to significant improvements in various aspects of operations. These include process optimization, increased quality control, effective risk management, reduced labor costs, strategic outsourcing, sustainability, economic sustainability, technological integration, and customer satisfaction. By implementing the findings of such research, manufacturing companies can achieve sustainable cost savings, improve operational efficiency, and gain a competitive advantage in the marketplace .
- Transparency of business performance: Evidence shows that companies adopting an integrated transparency approach add the most value to those companies compared to adopting an independent transparency approach . Management information systems also help determine the extent to which information about a company’s suppliers, sourcing locations, raw materials used, and associated risks and concerns is readily and transparently available to end users and other companies .
- Reducing time to market: One of the important components of the world-class manufacturing philosophy is reducing the waiting time for customers and delivering the product to the market, which if not taken into account, long times will lead to

increased costs due to larger buffer stocks and safety stocks. In addition, the longer the time to market for the product, the lower the market share of the product and the profit it generates; therefore, organizational performance is based on how the product's time to market is managed .

- Meeting customer expectations: World-class manufacturers always adopt a procedure that customers are willing to continue working with them. Knowing the expectations of customers regarding the products and services provided to them allows them to provide a product that is more satisfactory to the customer and this - in a long-term perspective - may improve the company's sales dynamics. This is why identifying customer needs in relation to products and other directly related components is a very important aspect of any organization's performance .
- Simplifying and making outsourcing processes more efficient: Manufacturers are gradually starting to implement a service outsourcing strategy and are collaborating with professional service providers to effectively reduce their service delivery costs while ensuring the quality of their products and services, which will lead to customer satisfaction (Holgado, & Niess,2023)

Since organizations that adopt world-class manufacturing need new ways to measure their performance, traditional performance measurement indicators are not valid for measuring world-class manufacturing practices because, based on old traditional cost management systems, lagging measures are linked to the company's strategy, are inflexible, costly, and conflict with continuous improvement (Fiksel & Croxton, 2021). The philosophy of world-class manufacturing for building products that can be sold in global markets has components that create specific performance. Some of these components are more important than others and have a greater impact on the manufacturing organization and its competitiveness.(Holgado, & Niess,2023)

Globalization has led to the expansion of trade between different nations, and thus competition has been extended from local and national markets to global markets. In these international markets, only organizations that have implemented world-class production can succeed in the global competition arena. In the meantime, the role of the supply chain is very essential for the country's production, suppliers are often the main sources of external risks that provide the prerequisites for the emergence of wide levels of disruptions in supply chains. Proper supply chain performance plays a key role in the success of an organization and the sustainable achievement of goals, especially its profitability. In this regard, the establishment of a supply chain performance evaluation system is recommended for its continuous improvement. (Rahimian and Rajabzadeh Qatari, 2016: 37-38).

2. Litreture review

Kumar and Singh (2024) examined how world-class manufacturing (WCM) capabilities contribute to supply chain shock absorption in the steel industry. Their study showed that key WCM pillars—including autonomous maintenance, focused improvement, and just-in-time flow—significantly enhance operational stability during disruptions. They reported that steel manufacturers with higher WCM maturity sustained more predictable output levels and recovered faster from supply interruptions, emphasizing the strategic value of disciplined WCM deployment in resilience building.

Almeida and Santos (2024) analyzed lean-driven resilience within integrated steel supply chains. They demonstrated that lean/WCM tools, such as value stream mapping, standardized work, and waste elimination, enhance responsiveness and reduce vulnerability to logistics bottlenecks. Their findings suggest that simplification and process stabilization not only

improve efficiency but also strengthen the steel supply chain's ability to withstand external shocks, especially in raw-material-dependent segments.

Rahman and Chowdhury (2024) explored the relationship between WCM, agility, and supplier integration in the Asian steel sector. Their results indicate that firms adopting strong WCM routines exhibit greater process stability, improved order-fulfillment agility, and more effective collaboration with upstream suppliers. The authors argue that WCM-driven standardization and continuous improvement provide a foundation for resilient partnerships and better risk-sharing mechanisms across the supply chain.

Zhang and Li (2025) investigated the role of digital WCM systems in strengthening supply chain resilience among Chinese steel enterprises. Their research highlights that integrating Industry 4.0 technologies—such as predictive maintenance, smart sensors, and cyber-physical systems—enhances real-time visibility and reduces operational uncertainty. These digital WCM capabilities were found to improve recovery time after machinery failures and labor disruptions, making them essential components of modern resilient steel supply chains.

Smith and Rodriguez (2025) assessed sustainability-oriented WCM practices and their impact on steel supply chain resilience. They concluded that circular material flows, energy-efficient production methods, and environmentally aligned WCM pillars reduce dependence on volatile raw materials and mitigate regulatory risks. Their study shows that adopting sustainable WCM not only improves environmental performance but also enhances adaptability and robustness against supply shortages and environmental disruptions.

3. Research method and data

This research aims to design a dynamic model of a resilient supply chain for world-class production in a descriptive manner with a modeling approach and at a macro level. In terms of its applied purpose and in terms of its descriptive survey data collection and its time period, it is a cross-sectional study and in terms of identifying the relationships between the research variables, it is of the correlation type and in terms of its approach and method of collecting the required data, it is classified in the mixed-exploratory research group (a combination of qualitative and quantitative methods). Given the importance and necessity of the resilience of the steel industry supply chain, the present research is applied in terms of its purpose and descriptive survey in terms of its method. The reliability of the measurement instrument was evaluated using Cronbach's alpha. All constructs achieved a Cronbach's alpha coefficient greater than 0.7, indicating acceptable internal consistency (Nunnally, 1978). This confirms that the items within each construct reliably measure the intended concepts related to world-class manufacturing (WCM) practices, supply chain, innovation, and performance in the steel industry.

For example, Cronbach's alpha values for the main constructs were as follows: WCM Practices ($\alpha = 0.82$), Supply Chain Resilience ($\alpha = 0.85$), Maintenance & TPM ($\alpha = 0.80$), and Digitalization / Industry 4.0 ($\alpha = 0.83$).

Population, Sample Size:

The statistical population of this study consists of managers, production supervisors, maintenance engineers, and supply chain professionals working in medium- and large-scale steel manufacturing companies. These participants were selected because they are directly involved in implementing world-class manufacturing (WCM) practices and managing supply chain operations.

Given the size of the population and the organizational dispersion of employees across multiple departments, the sample size was determined using Cochran's formula for an unknown population size, resulting in a minimum required sample of approximately 200 respondents. To ensure adequate representation and to increase statistical power, the sample

size was increased to 230 participants.A stratified random sampling method was employed. First, the population was divided into four relevant strata: (1) production, (2) maintenance, (3) quality, and (4) supply chain/logistics. Then, proportional random sampling was used within each stratum to ensure that the views of all key operational groups were fairly represented. This approach was chosen because WCM implementation and resilience capabilities vary across organizational units, and stratification significantly improves the accuracy and generalizability of the results.Participation was voluntary, and data were collected through a structured questionnaire distributed both electronically and in paper format. This sampling strategy ensured that the final dataset reflected a diverse and balanced cross-section of expertise within the steel manufacturing sector.

4. Analysis and discussion

The data required for the present study were collected from a questionnaire whose validity (as mentioned in the third chapter) was tested. The researcher used a questionnaire consisting of 21 questions, all of which were in the form of a five-choice Likert scale, to collect data. These data were analyzed by LISREL software, and in this chapter, the analyses performed to reject or confirm the research hypotheses are presented.

In the present study, after drawing the analytical model of the research based on the data by the Path diagram program by running the Perlis program from the LISREL software, a measurement model was obtained, in which the hypotheses were tested using B coefficients and the t-test. In addition, the model fitness indices were automatically calculated by running the Perlis program for the desired model .

According to the presented equations and solving these equations using the maximum likelihood method, the value of each coefficient in the figures and the interpretation of each coefficient are given in the following tables.

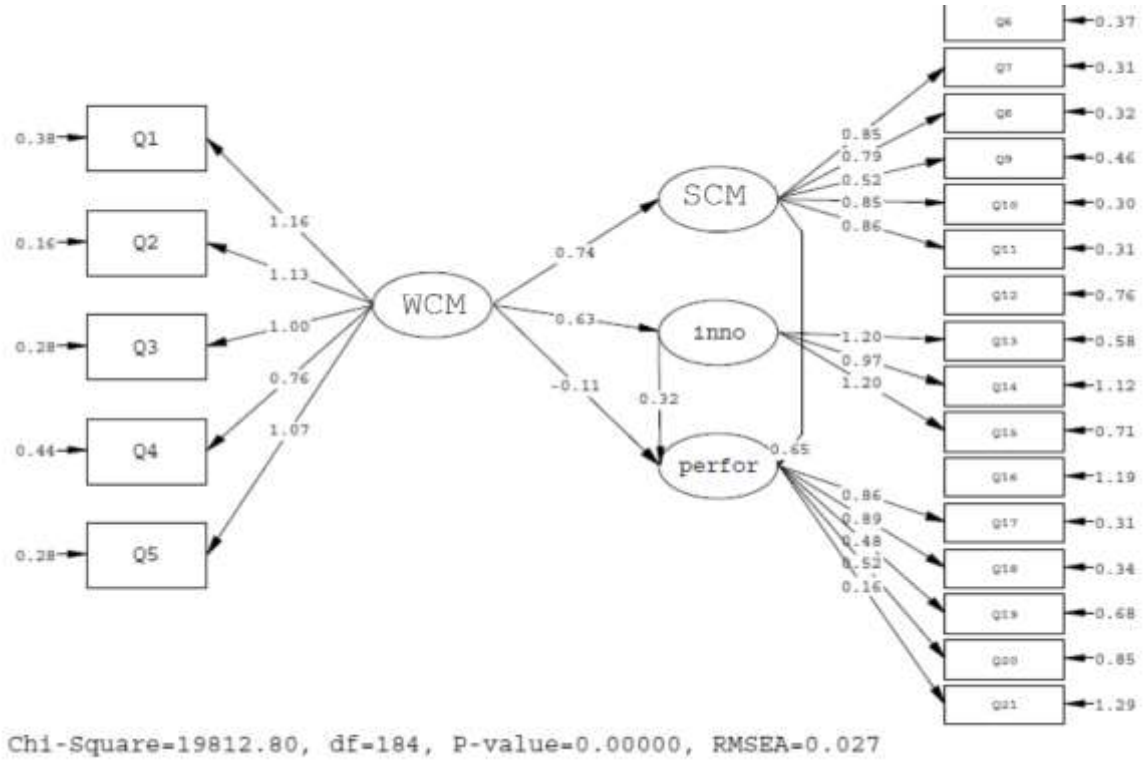

Figure 1. Estimated value of each path coefficient

Also, in order to evaluate the significance of each coefficient, a T-test was used, and the values of this test are given in Figure (2).

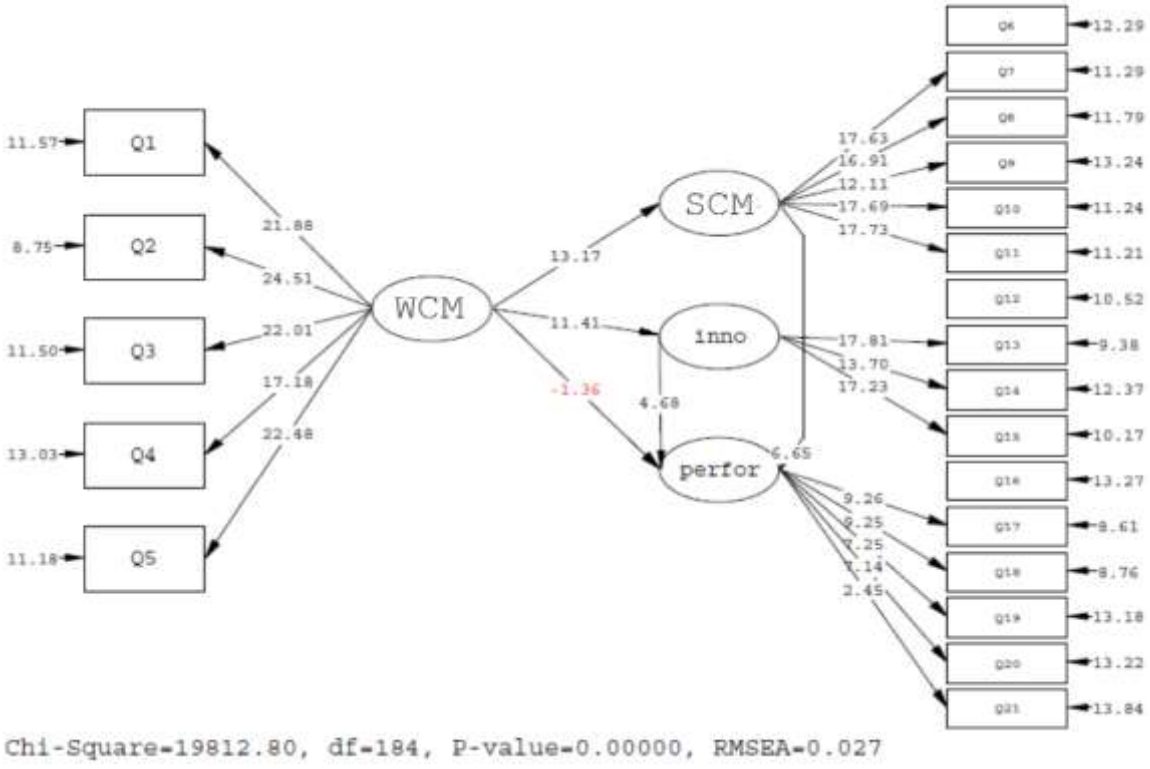

Figure 2. The value of the t-statistic for each of the coefficients

5. Conclusion and Suggestions

Market orientation has a mediating role that has a positive effect on the relationship between world-class manufacturing and supply chain resilience. According to the results obtained, this hypothesis has been confirmed with the structural coefficients of 0.74 and 0.65 and t-statistics of 13.17 and 6.65. World-class manufacturing (WCM), as a key management tool of the new century, is a systematic strategy and processes of defining, acquiring, transferring and applying information and knowledge by individuals in organizations, which creates innovation, competitive ability and improves productivity, and while helping with problem solving, decision-making, strategic planning, dynamic learning, etc., it prevents the deterioration of intellectual assets and increases the organization's awareness and increases the flexibility and resilience of the organization's supply chain.

This study demonstrates that World-Class Manufacturing (WCM) practices significantly enhance supply chain resilience in the steel industry. WCM contributes to operational stability, process standardization, and improved asset reliability, which collectively reduce the risk of disruptions and enable faster recovery. Importantly, the analysis reveals that the impact of WCM on supply chain resilience is partially mediated by innovation and firm performance. That is, WCM practices not only directly strengthen resilience but also indirectly enhance it by fostering innovative capabilities—such as process improvement, digital adoption, and flexible problem-solving—which, in turn, improve operational and supply chain performance.

The findings of this study are largely consistent with and extend the results of previous research on WCM and supply chain resilience. Similar to Kumar and Singh (2024), this study

confirms that WCM practices enhance operational stability and reduce vulnerability to disruptions in steel manufacturing. In line with Almeida and Santos (2024), our results show that lean and process-standardization tools contribute to faster recovery and stronger supply chain responsiveness.

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Declaration of Competing Interest
The author has no conflicts of interest to declare that are relevant to the content of this article.

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