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The Role of Green Supply Chain Management in Sustainable Business Performance with Emphasis on the Role of Managerial Innovation and Green Technology

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Abstract

This study was conducted with the aim of investigating the role of green supply chain management in sustainable business performance, emphasizing the role of managerial innovation and green technology. In this study, a survey questionnaire was used to collect information related to the analysis of hypotheses, which is also considered as a field method in this study. The statistical population included managers of industrial companies present in the industrial estates of Guilan province, and accordingly, the sample size was 384 people, and the same number of questionnaires were distributed and collected. The information collected by the questionnaires was analyzed using SPSS24 and AMOS24 software using structural equation modeling. The results showed that green supply chain management has a positive and significant effect on green technology innovation, green management innovation, and sustainable business performance. Also, green technology innovation and green management innovation have a positive and significant effect on sustainable business performance. Green supply chain management, as a key factor, plays a significant role in promoting green technological and management innovations. These innovations not only help improve environmental performance, but also have a positive impact on sustainable business performance. In other words, businesses that seek to achieve sustainability in their business can pave the way for the development of green innovations in technology and management by focusing on green supply chain management.

Keywords: Sustainable business performance, green technology, green supply chain management, management innovation.

Introduction

Green supply chain management has emerged as a critical approach to achieving sustainable business performance, especially in light of increasing environmental concerns and stakeholder demands. Despite its growing acceptance, the mechanisms through which green supply chain management impacts sustainability remain unknown. For example, while practices such as green manufacturing, eco-design, and green procurement are known to reduce resource consumption and waste, their direct impact on operational efficiency and profitability needs further investigation (Ahmed et al., 2022). Furthermore, the mediating role of environmental performance in linking green supply chain management practices to overall business outcomes highlights the need for a comprehensive framework that integrates economic, environmental, and operational dimensions. This gap emphasizes the importance of studying how green supply chain management can simultaneously address environmental sustainability and enhance competitiveness in industries facing regulatory pressures and market changes (Abdullah and Al-Ghuwain, 2020). Furthermore, the complexity of implementing green supply chain management across industries raises important questions about its scalability and effectiveness. For example,

companies in developing countries often face challenges such as limited access to green technologies and inadequate regulatory support, which can hinder the adoption of sustainable practices. Understanding these barriers is essential for designing policies and strategies that enable businesses to effectively integrate green supply chain management into their operations. Furthermore, as global supply chains become increasingly interconnected, the role of collaboration between suppliers, manufacturers, and customers becomes central to achieving sustainability goals. This research question seeks to address how to optimize green supply chain management practices to balance environmental protection with economic growth while ensuring long-term resilience and profitability for businesses operating in complex supply chain networks (Khan et al., 2022; Green et al., 2012).

Green supply chain management practices have become a critical necessity for businesses aiming to address growing sustainability challenges. With increasing global concerns about environmental degradation, resource scarcity, and climate change, industries are under unprecedented pressure to innovate and implement sustainable practices (Rapidcho and Enyong, 2024). Green supply chain management practices, which include green design, purchasing, manufacturing, and marketing, not only reduce environmental impacts but also increase operational efficiency and competitive advantage (Alkaran et al., 2025). Recent studies emphasize that integrating green innovations into supply chain processes can significantly contribute to sustainability goals, especially in high-impact industries such as manufacturing and services. However, existing research often lacks discussion of potential externalities and long-term sustainability, especially in low- and middle-income economies. Bridging this gap involves integrating industry-specific insights and institutional theory to understand the contextual pressures that shape sustainability adoption (Al-Khatib, 2024; Iqbal et al., 2023). Green supply chain practices involve integrating environmental thinking into supply chain management, from raw material procurement to product delivery and disposal. Manufacturing and service industries play a critical role in sustainability, with manufacturing sectors such as textiles, pharmaceuticals, and cement contributing to significant environmental impacts, and service sectors such as logistics, information technology, and healthcare impacting indirect environmental outcomes (Khan and Hamza, 2025). While these industries face increasing regulatory and consumer demands for sustainable performance, they also present opportunities for innovation through green technology and management practices. Resource-efficient production processes in manufacturing and energy-efficient operational systems in services have been considered as drivers of environmental performance and stakeholder satisfaction (Mahar et al., 2025). Green supply chain management is recognized as a key strategy for achieving sustainable business performance, but the mechanisms of its impact on environmental, economic, and social sustainability, especially in the areas of managerial innovation and green technology, are not fully understood. Recent research shows that organizations face challenges in integrating innovative management practices (such as organizational agility and top management commitment) and green technologies (such as artificial intelligence and the Internet of Things) into their supply chain processes. For example, the study shows that digital technologies such as blockchain and data analytics can improve transparency and carbon tracking, but lack of coordination among stakeholders and resistance to change prevent this potential from being fully realized. The research also emphasizes that innovation in supply chain management (such as green partnerships with suppliers) leads to sustainability only when integrated with waste reduction and energy optimization strategies. The importance of this research is in light of the increasing impact of supply chain activities on greenhouse gas emissions and natural resource consumption. The integration of green technologies (such as renewable energy systems) and management innovations (such as green organizational culture) can not only reduce the environmental footprint, but also increase profitability by reducing operating costs and improving competitiveness. The study shows that top management commitment and employees' environmental citizenship behaviors, as factors of management innovation, play a key mediating role in transforming green supply chain management into sustainable performance. In addition, there is a research gap in the field of the simultaneous impact of smart technologies and modern management practices on supply chain sustainability. Supply chain digitalization alone is not enough to achieve green goals and requires alignment with management strategies such as supply agility and collaboration with business partners. By examining the interaction of these factors, this research provides a comprehensive framework for understanding how to optimize green supply chain management towards achieving sustainability, which is crucial for policymakers, managers, and researchers in the fields of environment and business.

Theoretical foundations and research background

The resource-based perspective assumes that companies achieve competitive advantages by utilizing valuable, scarce, non-repeatable, and non-substitutable resources. Monizo et al. (2024) view green supply chain management practices such as green purchasing, production, and marketing as strategic resources that increase operational efficiency and environmental stewardship, thereby contributing to sustainability. Dynamic capabilities theory complements the resource-based perspective by emphasizing the need for companies to develop capabilities that allow them to adapt to changing environments (Correa et al., 2021). Green innovations, such as green technology innovation and green management innovation, demonstrate such dynamic capabilities and enable firms to effectively respond to regulatory pressures and market demands for sustainability (Yuan and Cao, 2022). Institutional theory explains how external forces—such as government policies, market competition, and consumer expectations—shape firms' adoption of sustainability. Organizations respond to institutional pressures (e.g., regulatory frameworks and industry standards) by integrating sustainability practices into their supply chains (Amanta and Ramsey, 2010). Regulatory inefficiencies and cultural resistance to change act as barriers to green supply chain adoption. Addressing these issues requires industry-specific strategies that address the unique operational challenges in manufacturing and service sectors.

address. In addition, subsectoral challenges in manufacturing and services require deeper exploration to understand changes in sustainability adoption.

Green supply chain management practices integrate environmental concerns into supply chain processes, from procurement to production, delivery, and disposal. These practices include green purchasing, green design, green manufacturing, and green marketing, all of which aim to minimize the environmental impacts of supply chains. Studies have shown that green supply chain management not only helps companies reduce their environmental losses, but also helps increase their operational efficiency and profitability, highlighting the role of external pressures (regulatory standards and market competition) in influencing companies to adopt green supply chain management practices. In addition, the increasing demand for environmentally friendly products has encouraged companies to implement sustainable practices to maintain a competitive advantage. For example, green manufacturing minimizes waste and emissions while improving resource utilization, and green marketing strategies align brand image with consumer expectations for sustainability. In manufacturing industries, green supply chain management practices play an important role in addressing resource-intensive processes, while in service industries such as logistics and information technology, they help reduce indirect environmental impacts. However, despite the direct effects of green supply chain management on firm sustainability, their role in fostering innovations such as green technology and management practices remains unknown (Mahar et al., 2025). In a study titled Sustainability Transformation through Green Supply Chain Management Practices and Green Innovations in Pakistani Manufacturing and Service Industries, Mahar et al. (2025) examined the impact of green supply chain management practices on firm sustainability performance in Pakistani manufacturing and service industries. Unlike previous research, which mainly focuses on the direct impact of green supply chain management practices, this study advances knowledge by combining green technology innovation and green management innovation as mediators and green organizational culture as moderators. The study draws on survey data from 480 industry professionals and uses partial least squares structural equation modeling (PLS-SEM) and multi-group analysis. The results suggest that green supply chain management practices significantly enhance sustainability outcomes, especially when green innovations are used. Furthermore, the impact of green supply chain management practices is more pronounced in the manufacturing sector, emphasizing the role of regulatory pressures and technological advances.

Merdiunci et al. (2024) conducted a study titled Reverse Logistics Practices in Humanitarian Supply Chain Management: A Content Analysis. This study aimed to analyze the area of application of reverse logistics in humanitarian supply chain operations and to indicate where it could be used in the future. In line with the research objective, annual reports and publications of relief organizations operating in Turkey were analyzed using content analysis method and semi-structured interviews were conducted with experts from humanitarian aid organizations. It is concluded that humanitarian aid organizations are aware of reverse logistics processes and their application areas are limited and there is a possibility of their application in the future. Adoption of reverse logistics processes in humanitarian supply chain management by disaster relief organizations can ensure efficient and cost-effective reuse and recycling of disaster relief resources. Stanek et al. (2023) in their study titled Supply Chain Agility and Sustainability Performance: A Configurational Approach to Sustainable Supply Chain Management Practices

examined different potential combinations of firm and supply chain sustainability practices and supply chain agility that lead to high firm performance. This study uses resource coordination theory and uses a configurational approach and qualitative comparative analysis method. The findings show that high sustainability performance can be achieved through different paths (equilibrium) that involve high and low values of each proposed sustainability scheme and supply chain agility (asymmetry). The findings also show that the results depend on how the practices are combined, rather than their individual effects.

Fadhil and Al-Husseini (2023) conducted a study titled The Role of Electronic Human Resources Practices in Sustainable Human Resources Management. The aim of this study is to identify the definitions of sustainable human resources management through a theoretical framework, covering the definitions provided by many researchers and trying to achieve a new definition. This study measured the impact of electronic human resources practices on sustainable human resources management in the Ministry of Higher Education and Scientific Research of Iraq by serving 180 employees. The partial least squares (PLS) method in the Smart PLS statistical program (version 4.0.8.9) was used as a statistical method for data analysis. The results of the study showed that the functions of electronic human resources on sustainable human resources management in the Ministry of Higher Education and Scientific Research are relatively acceptable. The most important recommendation of this study was that if the ministry wants to encourage the adoption of new working methods such as sustainable human resources management, it should introduce digital technologies such as artificial intelligence and machine learning in the development and continuous training of employees.

In a study titled The Impact of Lean and Agile Strategies on Supply Chain Risk Management, Ahmed and Houma (2021) presented a conceptual framework for analyzing empirical factors of the effectiveness of lean and agile supply chain strategies in risk management in terms of creating a strong and resilient supply chain. Data were collected from 140 supply chain professionals in the manufacturing industry. Structural equation modeling was used to test the hypotheses. The findings of this study indicate that market orientation as an external force has a greater impact on advancing agile strategy than lean, while quality management system as an internal force is highly related to the development of lean supply chain strategies. In addition, lean and agile strategies also have a significant impact on strong supply chain and flexible supply chain.

Research Hypotheses

In order to achieve the research objectives, the hypotheses were designed as follows:

1- Green supply chain management has a significant impact on sustainable business performance.

2- Green supply chain management has a significant impact on green technology innovation.

3- Green supply chain management has a significant impact on green management innovation.

4- Green technology innovation has a significant impact on sustainable business performance.

5- Green management innovation has a significant impact on sustainable business performance.

The conceptual model of the research is based on the research of Mahar et al. (2025) as shown in Figure 1. The role of green supply chain management on sustainable business performance with emphasis on the role of management innovation and green technology

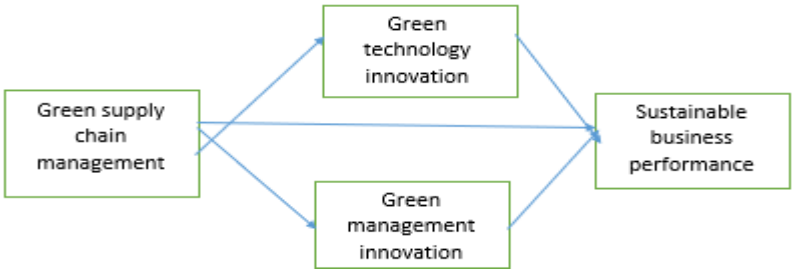

Figure (1): Conceptual model of the research

Research methodology

The present research is in the field of applied and survey research in terms of purpose and in terms of method; correlation is based on structural equations. In correlation research, the relationship between variables is analyzed based on the purpose of the research. In structural equation modeling, data is converted into covariance or correlation matrices and a set of regression equations between variables is compiled. Data and information related to theoretical foundations and research literature have been collected from articles, books, websites and libraries, which is referred to as the library method. To collect information related to the analysis of hypotheses, a questionnaire was used as a survey, which is also referred to as a field method in this research. The statistical population includes managers of industrial companies present in the industrial estates of Guilan province. Due to the uncertainty of the total population, a sample of 384 people was considered based on the Morgan table and the same number of questionnaires were distributed and collected.

The data collection tool in this study is a questionnaire. In this study, a standard questionnaire based on the research of Mahar et al. (2024) was used to collect data. The questionnaire was designed in such a way that respondents set the options based on a five-option Likert scale from completely agree to completely disagree. The questionnaire that was used as a data collection tool was distributed to the respondents in person and consists of two parts, the first part of which is related to the personal characteristics of the respondent and includes age, gender, work experience and level of education. In the second part, questions related to the research variables were raised, which consisted of 15 questions. In order to determine the reliability of the questionnaire, Cronbach's alpha coefficient was calculated using SPSS software. Considering that the minimum reliability coefficient for research questionnaires is 0.70, it is observed that the Cronbach's alpha coefficients obtained for all variables are higher than this value. Therefore, it can be claimed that the reliability and validity of the research questionnaire were desirable. Table 1 shows the results of the Cronbach's alpha coefficient.

Table (1): Results of the reliability of the questionnaire

Cronbach's alpha coefficient	**Questions**	Questionnaire
0.845	1-4	Green Supply Chain Management
0.901	5-8	Green Technology Innovation
0.874	9-11	Green Management Innovation
0.845	12-15	Sustainable Business Performance
0.940	1-15	Total Questionnaire

Research findings

The present study uses descriptive and inferential statistical methods to analyze the information collected from the statistical sample. In fact, first, using SPSS software, each variable was described in the form of tables and statistical indicators, and then, for data analysis, hypothesis testing, and in general, for generalizing the results from the sample to the statistical population, the structural equation modeling method was used using Amos 24 software. Table 2 shows the results of descriptive statistics of the research variables.

Table (2): Descriptive statistics of research variables

Number	Minimum Value	Maximum Value	Skewness	Skewness	Standard Deviation	Mean	Variable
384	5.00	1.00	0.575	-.375	0.523	3.655	Green supply chain management
.384	5.00	1.00	-0.7550	-.0311	0.654	3.385	Green technology innovation
.384	5.00	1.00	0.174	0.151	0.477	3.420	Green management innovation
.384	5.00	1.00	0.185	0.136	0.511	3.381	Sustainable business performance

Because the skewness and kurtosis of all variables are in the range of -2 and +2. All variables have a normal distribution. Therefore, parametric techniques are used to examine the research hypotheses. The conceptual model of the research was mentioned in the previous sections. Before fitting the structural model, it is necessary to examine whether the 15 items observed in the questionnaire (including the questionnaire questions) reflect the 4 dimensions or concepts (research variables) including green supply chain management, green technology innovation, green management innovation, and sustainable business performance in a desirable way? The overall fit of the measurement model is determined by confirmatory factor analysis (CFA). The next figure shows the measurement model for this study. In this model, the observed variables and latent variables are identified with their main titles. The measurement model along with its modifications is shown in the next figure.

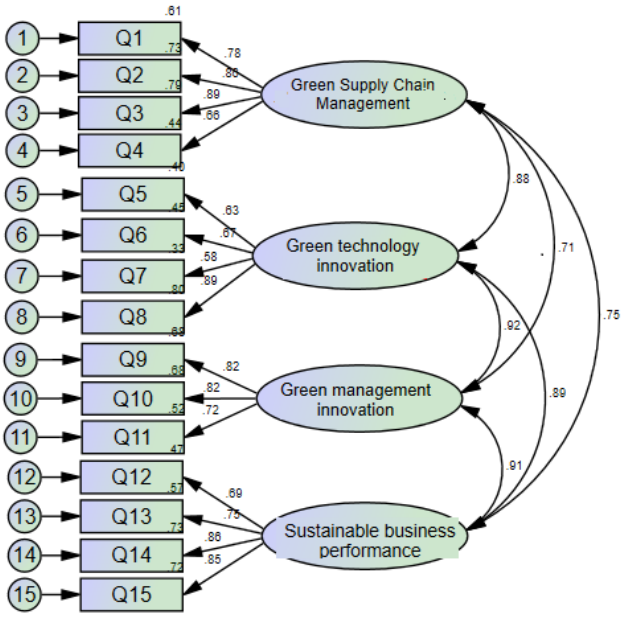

Figure (2): Factor analysis model with standardized coefficients

Before testing the hypotheses, it is necessary to ensure the validity and accuracy of the measurement models of the research variables so that structural relationships can be examined later. For this purpose, fit indices are used, which are shown in Table 3.

Table (3): Model fit indices

RMSEA	**NFI**	**CFI**	**TLI**	**IFI**	**GFI**	**CIMIN** ***df***	Model Fit Indices
0.006	**0.967**	**0.989**	**0.981**	**0.932**	**0.975**	**2.952**	Original Model
Smaller than 0.05	More than 0.9	More than 0.9	More than 0.9	More than 0.9	More than 0.9	1 تا 5	Acceptability Level

As can be seen from the above table, all the indices are within the desired range. Therefore, the suitability of the confirmatory factor analysis model in fitting the collected data is confirmed. In this section, the research structure model is fitted for examination. The hypothesis analysis model is shown in Figure 3 in the standard mode.

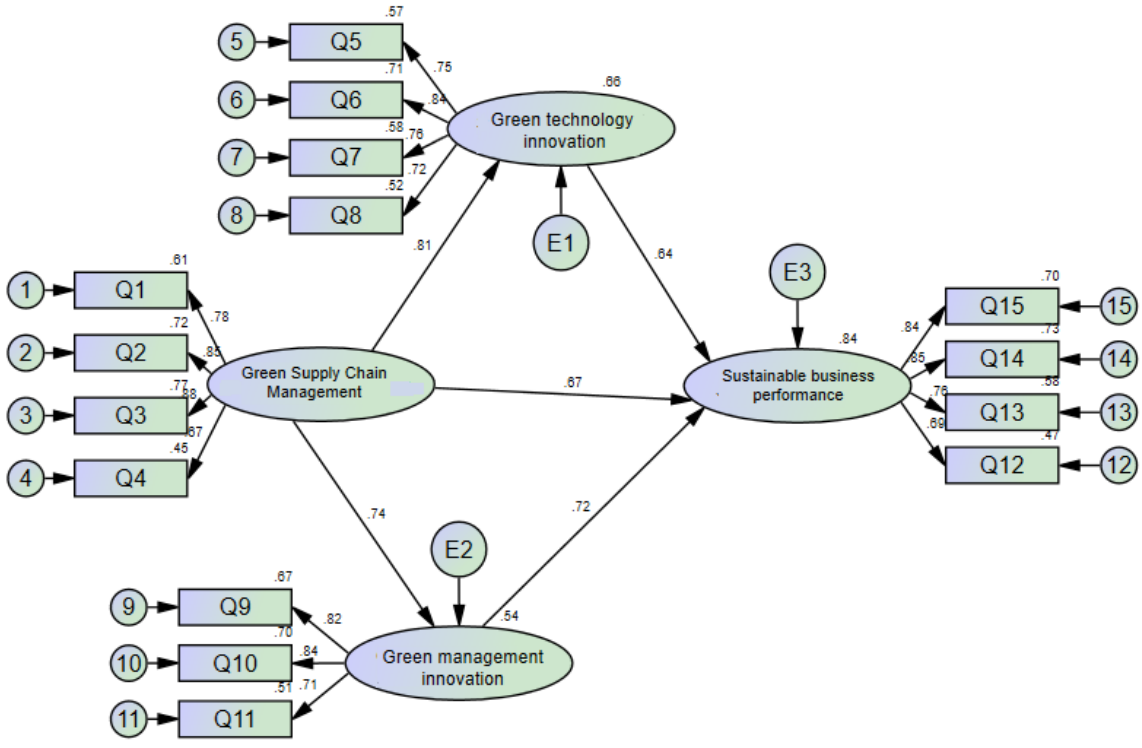

Figure (3): Structural model in standard form

According to the results of this model and the coefficients obtained from the structural analysis of the research data, the results of the structural path analysis (including the relationships of the latent variables with each other) are also presented below. Table 4 shows the results of the path analysis of the first hypothesis.

Table (4): Results of the first hypothesis

p-value	t-statistic	Standard deviation	Standardized coefficient	Path analysis
0.000	4.241	0.058	0.670	Green technology *innovation* → sustainable business performance

Based on the results of Table (4), the effect of green supply chain management on sustainable business performance is 0.670 and the obtained significance level (0.000) is less than five hundredths. Accordingly, green supply chain management has a positive and significant effect on sustainable business performance. Therefore, it can be stated that at a 95% confidence level, the first hypothesis of the study that green supply chain management has a significant effect on sustainable business performance is accepted. Table 5 shows the results of the path analysis of the second hypothesis.

Table (5): Results of the second hypothesis

p-value	t-statistic	Standard deviation	Standardized coefficient	Path analysis
0.000	5.980	0.150	0.811	Green technology *innovation* → sustainable business performance

Based on the results of Table (5), the effect of green supply chain management on green technology innovation is 0.811 and the obtained significance level (0.000) is less than five hundredths. Accordingly, green supply chain management has a positive and significant effect on green technology innovation. Therefore, it can be stated that at a 95% confidence level, the second hypothesis of the study that green supply chain management has a significant effect on green technology innovation is accepted. Table 6 shows the results of the path analysis of the third hypothesis.

Table (6): Results of the third hypothesis

p-value	t-statistic	Standard deviation	Standardized coefficient	Path analysis
0.000	5.609	0.128	0.738	Green technology innovation → sustainable business performance

Based on the results of Table (6), the effect of green supply chain management on green management innovation is 0.738 and the obtained significance level (0.000) is less than five hundredths. Accordingly, green supply chain management has a positive and significant effect on green management innovation. Therefore, it can be stated that at a 95% confidence level, the third hypothesis of the study that green supply chain management has a significant effect on green management innovation is accepted. Table 7 shows the results of the path analysis of the fourth hypothesis.

Table (7): Results of the fourth hypothesis

p-value	t-statistic	Standard deviation	Standardized coefficient	Path analysis
0.000	5.227	0.110	0.641	Green technology innovation → sustainable business performance

Based on the results of Table (7), the effect of green technology innovation on sustainable business performance is 0.641 and the obtained significance level (0.000) is less than five hundredths. Accordingly, green technology innovation has a positive and significant effect on sustainable business performance. Therefore, it can be stated that at a 95% confidence level, the fourth hypothesis of the study that green technology innovation has a significant effect on sustainable business performance is accepted. Table 8 shows the results of the path analysis of the fifth hypothesis.

Table (8): Results of the fifth hypothesis

p-value	t-statistic	Standard deviation	Standardized coefficient	Path analysis
0.000	5.240	0.205	0.718	Green technology innovation → sustainable business performance

Based on the results of Table (8), the effect of green management innovation on sustainable business performance is 0.718 and the obtained significance level (0.000) is less than five hundredths. Accordingly, green management innovation has a positive and significant effect on sustainable business performance. Therefore, it can be stated that the fifth hypothesis of the study that green management innovation has a significant effect on sustainable business performance is accepted at a 95% confidence level.

1- Green supply chain management has a significant effect on sustainable business performance.

2- Green supply chain management has a significant effect on green technology innovation.

3- Green supply chain management has a significant effect on green management innovation.

4- Green technology innovation has a significant effect on sustainable business performance.

5- Green management innovation has a significant effect on sustainable business performance.

Conclusion

The results obtained from this study showed that green supply chain management has a positive and significant effect on green technology innovation, green management innovation and sustainable business performance. Green technology innovation and green management innovation also have a positive and significant impact on sustainable business performance. These results are in some ways consistent with the research results of Mahar et al. (2025), Al-Kram et al. (2025), and Khan et al. (2022). By integrating digital technologies and environmentally friendly strategies, it acts as a key driver for the development of green technology innovation and green management innovation. According to previous research such as Lerman et al. (2022), organizations that implement green supply chain management improve transparency in carbon tracking and resource optimization by using intelligent systems (such as blockchain and cloud platforms). These technologies not only enable the rapid identification of environmental inefficiencies, but also pave the way for the design of energy-efficient products and sustainable production processes. On the other hand, Liao et al. (2022) state that green supply chain management, by enhancing green management innovation (such as organizational agility and green partnership with suppliers), leads organizations to adopt circular economy-based approaches and reduce waste. Cooperation

with suppliers that meet ISO 14001 requirements creates positive pressure to develop new management practices. Green technology innovation and green management innovation, in turn, enhance sustainable business performance through various mechanisms. Technologies such as artificial intelligence and data analytics reduce operating costs and increase long-term profitability by optimizing energy consumption and reducing carbon footprint. At the same time, green management innovation (such as a socially responsible organizational culture) expands market share by improving stakeholder relationships and gaining customer trust. Wang and Liu (2022) showed in a study of Chinese manufacturing companies that green innovation strategies (product, process, and service) directly improve financial and environmental performance, especially in the face of supply chain risks. In addition, integrating advanced technologies with management practices (such as green employee training) increases the resilience of organizations in crises such as the COVID-19 pandemic. Finally, combining green supply chain management with technological and managerial innovations creates a comprehensive framework for achieving business sustainability. Research emphasizes that supply chain digitalization alone is not enough and requires alignment with management strategies (such as supply agility and collaboration with green partners). The use of advanced technologies alongside recycling and biodegradable packaging policies ensures sustainable performance in economic, social, and environmental dimensions. These findings suggest that organizations must simultaneously focus on green technologies, innovative management practices, and stakeholder integration to achieve sustainability.

Practical suggestions for Iranian industrial companies in the field of green supply chain management include; Companies should share sustainable knowledge and technologies (such as advanced recycling systems or renewable energies) by creating green collaboration networks with suppliers and competitors. These partnerships not only reduce production costs, but also facilitate innovation in low-carbon product design. For example, the use of green raw materials (non-toxic and low-consumption) in industries such as automotive or petrochemical, in accordance with ISO 14001 standards, can reduce the environmental footprint by up to 30%. Also, implementing digital platforms (such as blockchain) to track carbon throughout the chain increases transparency and gains the trust of customers and investors. Training employees in data analytics and circular economy, as a key principle, also strengthens the ability of companies to adapt to green requirements. Companies should seek to create socio-environmental value by adopting a value-oriented approach to supply chain management, rather than focusing solely on reducing costs. This includes developing flexible production lines for waste recycling (in line with the Industry 4.0 approach) and designing products that can be disassembled and reassembled. For example, in the construction industry, the use of recycled materials and prefabricated technologies can reduce energy consumption by up to 40%. On the other hand, developing green performance indicators (such as reducing emissions per unit of production) and linking them to financial rewards for managers creates the necessary incentive for managerial innovation. Collaboration with research and academic centers to develop indigenous green technologies (such as carbon capture filters in the petrochemical industry) can also create a sustainable competitive advantage. Successful implementation of green supply chain management requires commitment from senior management, investment in digital technologies, and alignment with environmental laws (such as tax exemptions for green projects). Companies like Iran Khodro and Petrochemicals can act as pioneers of green transformation in Iran by modeling global experiences (such as General Motors) and localizing them.

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