

The Influence of Green Technology Innovation and Supply Chain Learning on Sustainability Performance in SMEs

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Abstract: Increasing attention to issues such as energy consumption, waste reduction, and resource efficiency has made the importance of sustainable performance more visible. The current research was conducted to investigate the impact of green technology innovation (GTI) and supply chain learning (SCL) on sustainability performance (SP). The study's statistical population consisted of managers of Small and medium-sized enterprises (SMEs) in Mobarakeh industrial town in Iran. The sampling method was a simple random method and 130 companies were determined by G*Power software to determine the sample size. The validity of the questionnaires was confirmed using content validity and construct validity and their reliability was obtained by Cronbach's alpha. The data was analyzed by structural equation modelling in SMART_PLS software. The research findings showed that GTI and SCL directly and significantly affect SP. According to the obtained results, GTI and SCL can be effective in improving SP in SMEs.

Keywords: environment; green technology innovation; SMEs; supply chain learning; supply chain management; sustainability performance

1 INTRODUCTION

In a world where most businesses are focused on generating wealth through economic performance, in today's dynamic business environment, companies face many challenges, including environmental issues [1]. These challenges, which are the result of inefficient methods of production and consumption, have become worrying for many countries in the world in recent years. To deal with these challenges, countries have introduced several strategic measures such as "Sustainable Development Goals" [2]. Some sources have said that small and medium-sized enterprises (SMEs) can cause more than 50% of industrial pollution that leads to environmental damage [3]. Therefore, organizations must focus their progress on measuring sustainability performance (SP) instead of focusing only on operational and economic performance to improve their sustainability indicators [4].

In providing new services and products, organizations adopt different methods to improve SP, which can be mentioned in green technology innovation (GTI) and supply chain learning (SCL). With the rapid development of the economy, innovation has become a key element for sustainable and healthy competitive development [5], and in this regard, to develop sustainable practices and pay attention to issues such as greenhouse gas emissions, energy efficiency and waste reduction, companies should focus on technological innovations [6]. The innovative activities of technology in the traditional form have indeed produced many material improvements, but also caused a lot of environmental damage, which is why even with the high costs of implementation and training of employees, green technology innovation replaces the traditional approach to improvement. It has become the SP of companies [7]. For shareholders of manufacturing companies, it is attractive in financing that GTI can improve the image, credit and reputation of the companies. In addition to creating a competitive advantage for companies, innovation in green technology can also improve social welfare and

environmental sustainability in companies. In addition, GTI reduces the emission of greenhouse gases, which leads to the optimal use of renewable energy sources [8].

In addition, SMEs as forward-looking organizations are of great importance due to their poor knowledge of their supply chain and sustainable production processes, and to compete at the national and global level, they need effective supply chain management and must cooperate with all members of the chain. Provide cooperation [9]. Today, companies focus on achieving sustainable performance, apart from competitive advantage, by collaborating with various supply chain partners. Companies mainly work together to improve individual and supply chain performance against turbulent environments. Finally, the focus of the supply chain performance has been extended to environmental and social aspects in addition to the conventional economic aspect [10]. SCL shows the knowledge related to sustainability in the learning process with the aim of social, environmental and economic issues. This is essential for the successful implementation of sustainability and performance among supply chain members [11].

Masoudi and Shahin (2025) [8] and Masoudi and Emamiyan (2025) [12], in their research concluded that GTI has an impact on SP. Also, according to the research done by Yang et al. (2023) [13] and Sun et al. (2023) [14], SCL affects sustainability performance.

According to the review of the available literature, few studies have specifically addressed the hypotheses of the present research. It is also the first time that the impact of innovation and learning on performance is studied simultaneously. In addition, the current research has been studied in a developing country, and environmental issues in developing countries are more important than in developed countries. Today, paying attention to environmental issues, the quality of products and services, and sustainable performance in organizations such as small and medium-sized companies is considered one of the main characteristics of any developing organization, which plays an important role in the economic development of countries. Accordingly,

the current research discusses the effect of GTI and SCL on SP among SMEs.

In the subsequent sections of this study, we begin by outlining the theoretical underpinnings that form the basis of our research. Following this introduction, we will detail the proposed model and the associated hypotheses guiding our investigation. The methodology employed in this research will then be thoroughly described. To validate the proposed model, we conduct an empirical study, and based on the findings derived from this analysis, we will engage in a comprehensive discussion and draw conclusions.

2 LITERATURE REVIEW

In this section, we will review the research literature. First, we will explain the concepts of sustainability performance, GTI and SCL. Next, we will discuss the relationship between GTI and SP and the relationship between SCL and SP.

2.1 Sustainability Performance

The most well-known view about sustainability performance refers to three economic (financial), social and environmental aspects. Economic performance involves a plan of production that meets current and future needs. Economic performance shows the continued profitability and financial survival of an organization whose measurement depends on long-term operational value, cost-effectiveness, output, return on investment and market value. Social performance is concerned with the relationship between social conditions such as deprivation and ecological destruction, and the concept of social performance suggests that the reduction of deprivation should entail neither unjustified environmental destruction nor economic instability. Its purpose is to reduce deprivation in the dominant economic and environmentally compatible asset base of humanity. Environmental performance requires maintaining important environmental functions and therefore, maintaining the capacity of capital stock to provide those functions, in other words, the result of managing an organization is defined from its environmental aspects [15].

The coordination of environmental, social and economic goals to maximize values and growth in the long term in providing business activities is called the function of sustainability. For this reason, the efficient use of environmental, social and economic resources for current use and at the same time protection of current resources for future generations is called sustainable performance. Environmental sustainability performance is a vital centre among the dimensions of SP, which indicates the ability of a company to reduce its environmental impact. The evaluation of environmental performance includes a detailed examination of operational effects on the environment to reduce environmentally destructive activities. Economic SP is a valid sustainable aspect among the sustainability characteristics to increase the market values of companies. It includes financial benefits and serves as an indicator of financial stability and sustainable survival of a company.

Finally, social SP refers to diverse social factors such as improving employee performance, health, safety and social well-being, equal opportunities for advancement, and support for humanitarian initiatives [8].

2.2 Green Technology Innovation

Innovation, as a fundamental source of competitive advantage, has been considered in a wide range of studies, and for this reason, agents also attach great importance to innovation processes and consider it the basis for having a good competitive position [16]. Braun and Wield (1994) were the first to introduce the concept of GTI, which is defined as technologies and processes that improve the quality of the environment and reduce the use of raw materials [5]. GTI, which aims to promote technological innovation in green processes or products, has also been used in pollution prevention, waste reduction, resource recycling and other environmental management practices [17].

Green technology innovation consists of three dimensions: product innovation, process innovation and end-of-line management innovation. Green product innovation refers to the creation of environmentally friendly products using less, non-toxic resources and degradability. With this type of innovation, the sustainability, durability and recyclability of products can be increased. Green process innovation improves the performance of manufacturing and recycling processes. This type of innovation increases the design and implementation of production processes that are more suitable and sustainable for the natural environment. End-of-line management innovation refers to the integration of technological innovations that improve the efficiency of the treatment of three wastes: wastewater, waste gas, and waste residue. This type of technology contributes to the development of sustainable products by reducing input materials and energy requirements and increasing the life cycle of products [12].

2.3 Supply Chain Learning

The concept of SCL originates from the theory of inter-organizational learning. Bessant and Tsekouras in 2001 were the first to use the supply chain as a knowledge-sharing network [18]. SCL is an important process that is widely accepted by manufacturing and service organizations as an approach to business improvement through the collection and exploitation of information and knowledge by suppliers and customers [19]. To achieve sustainability, companies are increasingly establishing collaborative relationships with their supply chain partners. Supply chain literature shows that over time, the focus of companies' performance in the supply chain has progressed from economic aspects to environmental and social aspects [11].

Supply chain learning consists of three dimensions: supplier learning, customer learning and internal learning. Supplier learning refers to the exchange of knowledge between the company and suppliers. The company uses the experiences of suppliers to improve products and adopt new technologies, and monitoring systems are in place to

effectively utilize this knowledge. Customer learning implies that primary customers play a vital role in the SCL process. Using the information and knowledge provided by customers, the company improves product innovation, develops new technologies, and creates effective monitoring systems for optimal use of this knowledge. Internal learning in the supply chain refers to the exchange of information and knowledge between the internal units of the organization. This process includes effective communication of product information and innovation, learning from each other, promoting the adoption of new technologies and evaluating the application of product knowledge in different units, which helps to improve the overall performance of the organization [20].

2.4 The Influence of GTI on Sustainability Performance

Green technologies that affect energy become a leading factor in reducing environmental problems caused by the industrial revolution and effectively reduce carbon emissions by more than 60%. Pollution monitoring, waste management and clean technology are examples of GTI [21]. GTI refers to the development of new technologies or the improvement of existing technologies to minimize carbon production, conserve existing resources, and reduce pollution for the health of employees and the public. GTI refers to technological advances aimed at reducing harmful environmental impacts. For these reasons, researchers pay much attention to GTI and its role in sustainable development and competitive advantage [12].

Green technology innovation leads to rapid progress in new systems and equipment to protect the environment and natural resources, and as a result, improves the understanding of stakeholders and managers and helps companies improve economic output. Also, adopting this innovation reduces production, operation and processing costs and ultimately increases revenues and the overall economic performance of the company. Green technology innovation as a transfer mechanism enhances environmental performance through the successful deployment of digital finance helps reduce carbon emissions and improves renewable energy sources [8].

2.5 The Influence of SCL on Sustainability Performance

SCL has been proposed as an important way to manage inter-firm resources to achieve sustainability. Case findings show that SCL by considering environmental, social and economic aspects leads to better sustainability performance. Pursuing sustainability requires acquiring and sharing new knowledge about sustainability-related products, processes, and initiatives [11].

Learning in the supply chain helps improve environmental performance. Sustainable supply chain management theory emphasizes the importance of learning in responsible supply chain management, because this process facilitates the exchange of environmental knowledge between companies and suppliers and customers, and leads to achieving sustainable supply chain configurations and

improving environmental performance. In particular, information on environmentally friendly raw materials provided by suppliers is essential for companies to make responsible production decisions. Also, sharing information such as inventory levels and sales data among supply chain members can improve logistics efficiency and visibility and contribute to the effective use of resources, which ultimately leads to improved sustainability performance [14].

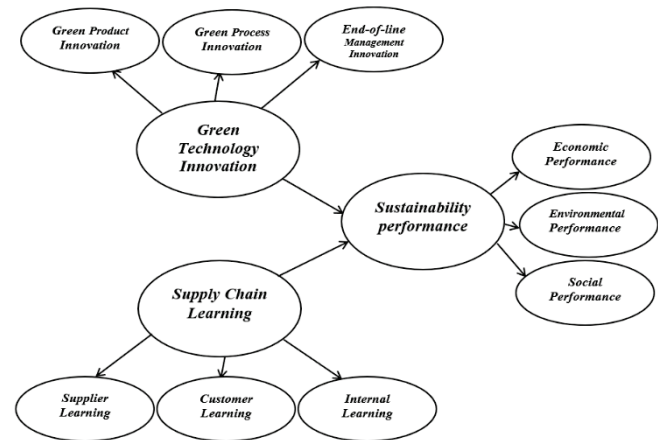


Figure 1 Research model

Fig. 1 presents the conceptual framework of the study. In this research, the independent variables identified are GTI and SCL, while the dependent variable is sustainability performance. Based on this, the hypotheses of this research are as follows:

- H1: GTI impact sustainability performance.
- H2: SCL impact sustainability performance.

3 METHODOLOGY

In this section, we will discuss the tools used to measure research variables and confirm the validity of its content. In the following, we will discuss the statistical population of the research, the method of data collection the sampling method and the reason for its use.

3.1 Measurement Instrument

A survey instrument was employed to assess the research variables. This questionnaire was divided into two sections. The initial section gathered demographic details about the participants, comprising three questions (Respondent's age, Respondent's level of education and Duration of the company). The subsequent section contained items pertinent to the research variables, i.e. GTI, SCL and SP. For this part of the questionnaire, 44 items were used. Also, the items were measured on a five-point Likert scale from 1 (completely disagree) to 5 (completely agree). The following studies have been used to measure the research variables.

Green technology innovation: For the GTI variable, we used the Wang et al. (2022) [22] research. This research measures GTI with 15 items and includes 3 dimensions: green product innovation (5 items), green process innovation (5 items), and end-of-line management innovation (5 items).

Supply chain learning: For the SCL variable, we used the Huo et al. (2021) [20] research. This research measures SCL with 15 items and includes 3 dimensions: supplier learning (5 items), customer learning (5 items) and internal learning (5 items).

Sustainability performance: For the SP variable from the research of Yang et al. (2023) [13] we used. This research measures SP with 14 items and includes 3 dimensions of economic performance (5 items), environmental performance (5 items) and social performance (4 items).

3.2 Sample Size and Data Analysis Approach

The statistical population of this research consists of quality managers of small and medium companies in Mobarakeh Industrial City. Data collection was conducted using a straightforward random sampling technique during the winter season of 2024. For this purpose, the list of companies was used for simple random sampling. This industrial townhouses more than 500 active small and medium companies. To establish the necessary sample size for PLS-SEM, we utilized G*Power software to conduct a power analysis based on the model configurations [23]. In this research, 130 data (quality managers of small and medium-sized enterprises) to achieve an 80% power level and identify R^2 values of no less than 0.1 while maintaining a 5% error margin, G*Power software was utilized to determine the required sample size. For this purpose, 15% more, i.e. 150 questionnaires were distributed among the companies, after collecting them and removing the questionnaires with incomplete information, the rest of the questionnaires were used for analysis. Also, the questionnaires were distributed to the respondents in person and reminders were made by telephone to increase the response rate. In addition, two expert academicians and two senior experts from the companies reviewed the survey items and the content validity of the questionnaire was confirmed.

The Kolmogorov-Smirnov (K-S) test indicated that the distribution of the constructs was not normal at a significance level of $p = 0.05$, which was attributed to the limited sample size ($n = 130$). Consequently, PLS-SEM was employed for data analysis [24]. In this paper, SEM was used because, according to Byrne (2013) [25], confirmatory factor analysis (CFA) is used to examine the theoretical and conceptual dimensions of visible and hidden scales in complex models. Causal inference is due to the nature of accessing and correcting the measurement errors observed in the detailed analysis, and for this reason, in the present study, PLS-SEM was used in the hypothesis analysis.

4 RESULTS

These results were obtained in the analysis of demographic variables. In terms of the duration of company activity, 46.93% of companies with more than 15 years of activity, equivalent to 61 companies, had the highest frequency, and 10.77% of companies, equivalent to 14 companies with less than 5 years of activity, had the lowest frequency. In terms of age, most of the respondents were

between 41 and 50 years old with a frequency of 44.61%, equivalent to 58 people, and managers less than 30 years old with 13.08%, equivalent to 17 people, had the lowest frequency. In terms of educational level, most of the respondents with a bachelor's degree with a frequency of 48.46%, equivalent to 63 people, and those with a higher degree than a bachelor's degree with 20%, equivalent to 20 people, had the lowest frequency in the statistical sample.

Table 1 Measurement Model

Construct	Label	Factor	C- α	CR	AVE
Green product innovation	GPt11	0.851	0.904	0.929	0.722
	GPt12	0.845			
	GPt13	0.884			
	GPt14	0.849			
	GPt15	0.818			
Green process innovation	GPs11	0.838	0.871	0.906	0.661
	GPs12	0.866			
	GPs13	0.876			
	GPs14	0.724			
	GPs15	0.749			
End-of-line management innovation	EMI1	0.786	0.879	0.911	0.673
	EMI2	0.765			
	EMI3	0.775			
	EMI4	0.788			
	EMI5	0.865			
Supplier learning	SL1	0.825	0.856	0.897	0.635
	SL2	0.842			
	SL3	0.845			
	SL4	0.795			
	SL5	0.793			
Customer learning	CL1	0.829	0.854	0.896	0.633
	CL2	0.846			
	CL3	0.768			
	CL4	0.770			
	CL5	0.761			
Internal learning	IL1	0.786	0.808	0.867	0.566
	IL2	0.719			
	IL3	0.731			
	IL4	0.783			
	IL5	0.741			
Economic performance	EcP1	0.830	0.853	0.895	0.631
	EcP2	0.738			
	EcP3	0.771			
	EcP4	0.769			
	EcP5	0.857			
Environmental performance	EnP1	0.753	0.840	0.887	0.611
	EnP2	0.737			
	EnP3	0.793			
	EnP4	0.787			
	EnP5	0.832			
Social performance	SP1	0.827	0.817	0.879	0.645
	SP2	0.785			
	SP3	0.836			
	SP4	0.762			

Regarding the research variables, Chin (2010) outlines that the analysis of studies using Partial Least Squares (PLS) involves two main stages: first, the assessment of the measurement model (external) and the evaluation of the structural model (internal); second, conducting tests on the measurement model. These tests are essential for verifying both the reliability and validity of the constructs involved [26]. As demonstrated in Tab. 1, all factor loadings for the constructs exceed the threshold of 0.7, thereby confirming the validity of the proposed model. This suggests that the

model is robust and adequately represents the underlying theoretical framework [27].

To assess the reliability of the external model, we utilized Cronbach's alpha ($C-\alpha$), composite reliability (CR), and average variance extracted (AVE). As illustrated in Table 1, both $C-\alpha$ and CR exceed the threshold of 0.7, indicating that the reliability of the variables is established. Additionally, the AVE for all constructs was found to be greater than 0.5, further confirming their reliability [24]. Furthermore, the composite reliability is confirmed as the value of CR exceeds that of AVE [28]. The results pertaining to discriminant validity are presented in Tables 2 and 3. According to Table 2, the square root of the AVE for each variable surpasses its correlations with other variables, indicating compliance with the standards set forth by Fornell and Larcker (1981) [29]. Additionally, Table 3 reveals that the HTMT ratios are below 0.9, thereby confirming the establishment of discriminant validity [30].

Table 2 Fornell and Larcker coefficients

	SP	EcP	EnP	GPsi	GPI	EMI	SL	IL	CL
SP	0.803								
EcP	0.356	0.794							
EnP	0.310	0.709	0.781						
GPsi	0.300	0.337	0.365	0.813					
GPI	0.559	0.394	0.359	0.292	0.850				
EMI	0.599	0.498	0.471	0.310	0.466	0.820			
SL	0.349	0.726	0.513	0.271	0.346	0.409	0.797		
IL	0.347	0.598	0.652	0.237	0.277	0.454	0.599	0.752	
CL	0.297	0.605	0.519	0.291	0.443	0.403	0.684	0.735	0.795

Table 3 HTMT criterion

	SP	EcP	EnP	GPsi	GPI	EMI	SL	IL	CL
SP									
EcP	0.418								
EnP	0.367	0.835							
GPsi	0.360	0.390	0.426						
GPI	0.640	0.446	0.409	0.316					
EMI	0.705	0.575	0.544	0.340	0.504				
SL	0.411	0.848	0.604	0.318	0.397	0.471			
IL	0.430	0.718	0.797	0.292	0.328	0.538	0.713		
CL	0.350	0.704	0.614	0.332	0.389	0.460	0.793	0.819	

In analyzing the structural framework of the research, a detailed three-phase approach was utilized. This approach involved measuring the R^2 value, assessing the quality of the Q^2 model, and evaluating the significance of the path coefficients present in the structural framework [31]. The findings from this analysis are presented in Tabs. 4 and 5, as well as Figs. 2 and 3, providing a clear overview of the model's performance and the relationships between variables. This systematic approach ensures a thorough understanding of how well the model fits the data and its predictive capabilities.

Table 4 R^2 , cross validity redundancy and communality

Variables	R^2	Redundancy index	Communality index
Sustainability performance	0.679	0.252	0.315

$$GOF = \sqrt{AVE \cdot R^2} = 0.661 \quad (1)$$

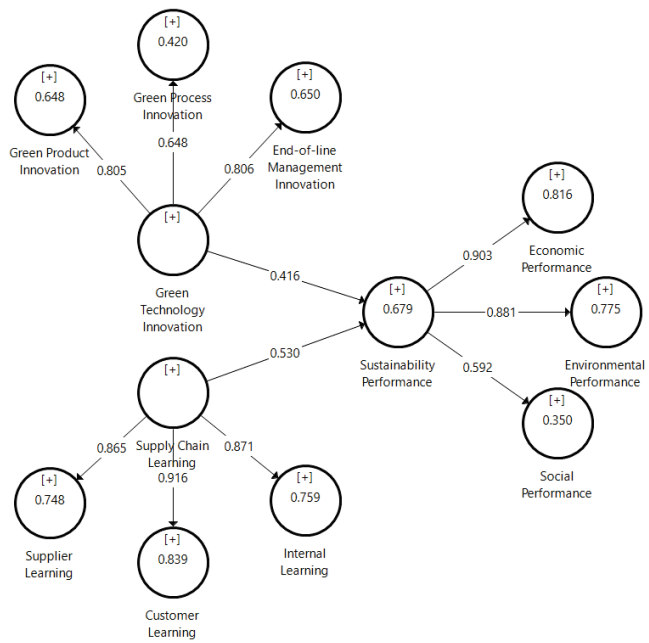


Figure 2 Path coefficient result

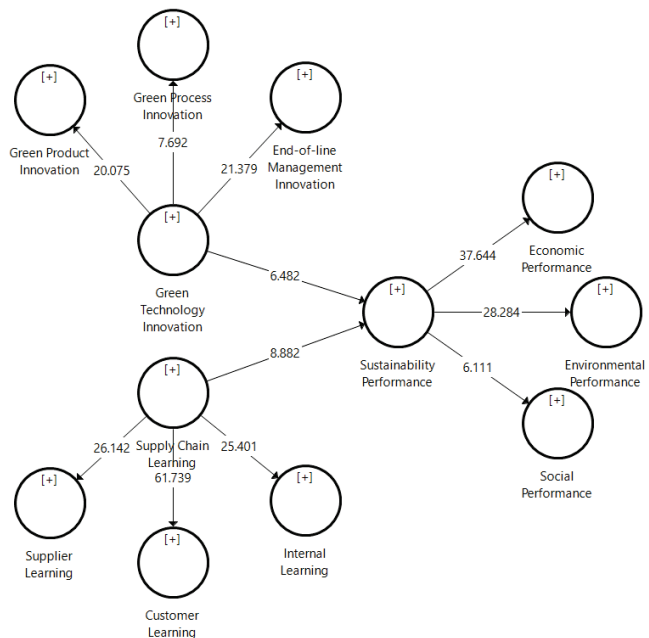


Figure 3 Z-value significant coefficients

Based on the thresholds of 0.25, 0.50, and 0.75, which represent low, medium, and high levels, the R^2 value indicating sustainability performance approached a high level [32]. Similarly, using the thresholds of 0.02, 0.15, and 0.35 for the redundancy index in the structural model of sustainability performance, it was found to be medium to high [23]. Furthermore, the communality index for sustainability performance also fell within the medium to high range. Lastly, employing the goodness of fit (GOF) test as outlined by Tenenhaus et al. (2005) and following Eq. (1), the overall research model was assessed. The resulting value of 0.661 indicated that the overall quality of the research model was high [33].

Also, In the evaluation of the structural model, the results indicate a good fit of the model with the data. The RMSEA is 0.06, which suggests an acceptable model fit. Additionally, the CFI is reported at 0.93 and the TLI is also 0.93, both of which are above the accepted thresholds for a good fit. These results demonstrate that the proposed model effectively explains the relationships among the variables and is statistically valid [34].

In conclusion, the analysis of the structural model involved utilizing path coefficient testing alongside the bootstrap method to evaluate the strength of the connections among the research hypotheses. As illustrated in Fig. 3 and Tab. 5, it is evident that both GTI and SCL influence sustainability performance.

Table 5 Hypotheses testing results

Hypothesis	Path coefficient	SE	t-value	p-value	Decision
GTI → SP	0.416	0.064	6.482	0.000	Supported
SCL → SP	0.530	0.060	8.882	0.000	Supported

As shown in Tab. 5, GTI has an effect of 0.416 (t -value = 6.482) on sustainability performance. Also, SCL has an effect of 0.530 (t -value = 8.882) on sustainability performance. The findings of this research hold significant practical implications for SMEs, as they indicate that investing in GTI and enhancing SCL can contribute to the improvement of their SP. In light of increasing social and environmental pressures, these companies can not only mitigate their negative environmental impacts by adopting these approaches but also gain a competitive advantage. These results can guide managers in designing effective strategies to achieve their sustainability objectives.

5 DISCUSSION

This part offers the examination and explanation of the research results, using a systematic method [34]. In recent years, the concepts of GTI and SCL have been linked with economic ideology, and a key result of GTI and SCL is sustainable performance. Utilizing GTI and SCL within both manufacturing and service sectors enables organizations to concentrate on their intended market, optimize their material and human resources, and enhance their competitive standing in the industry. However, due to the small sample size of the current research, which includes 130 small and medium-sized companies and is limited to only one industrial town in Iran, caution should be exercised in generalizing the findings to other fields. For example, it can be examined from different points of view: 1) Cultural and economic characteristics: Every country or region has its own cultural, economic and social characteristics that can affect the acceptance and implementation of GTI and SCL concepts. For example, small and medium enterprises (SMEs) in developed countries may have better infrastructure and financial resources to implement these concepts. 2) Diversity in industry: Different industries may have different needs. For example, companies in the IT sector may use GTI and SCL more than companies in the manufacturing or service

industries. 3) Resource limitations: Small and medium enterprises in developing countries may face more limitations in human and financial resources, which can affect their ability to implement the desired concepts. 4) Local laws and regulations: Local laws and regulations can affect how companies operate. For example, environmental requirements in one country may be much stricter or easier than in another.

The present research was conducted on SMEs in Mobarakeh Industrial Town in Iran. For this purpose, a questionnaire was used in data collection. The quality managers of these companies were responsible. According to Tab. 5, in the first hypothesis of the research regarding the effect of GTI on SP, considering that its t -value is 6.058, which is outside the range (-1.96, 1.96), the p -value is less than 0.05, and the intensity of the effect 0.416 shows the positive and significant effect of GTI on SP. In the second hypothesis of the research about the effect of SCL on SP, considering that its t -value is 9.021, which is outside the range (-1.96, 1.96) the p -value is less than 0.05, and the intensity of the effect is 0.530. It shows the positive and significant effect of SCL on sustainability performance.

5.1 Theoretical Implications

About the importance of SMEs in environmental issues and the impact of GTI and SCL on sustainable performance in these companies, the results of this research have important theoretical implications. The first research hypothesis, the impact of GTI on sustainability performance, was accepted with an impact rate of 0.416. The result of the research with the research results of Masoudi and Shahin (2025) [8] and Masoudi and Emamiyan (2025) [12] is similar. The confirmation of this hypothesis shows that the performance and survival of companies strongly depend on their innovation, and one of the ways to achieve business sustainability is to adapt to technological advances. The goal of innovation is to create new technologies and features, optimize the current process by integrating existing technologies, and increase knowledge about the interrelationship of processes and tasks, as well as about adding values to current structures and processes. Growth and development in green technologies increase environmental innovations and consequently increase environmental productivity. Specifically, GTI helps companies find creative solutions to environmental, economic, and social issues. From another perspective, sustainable performance can be created when companies develop innovative strategies. The company's innovation acts as an internal driver in creating green capabilities. Eco-innovation enhances brand reputation, attracts environmentally conscious consumers, and creates new market opportunities, resulting in long-term financial benefits. In addition, the impact of clean technology on sustainable performance cannot be ignored.

The second hypothesis of the research, the effect of SCL on sustainability performance, was accepted with an effect rate of 0.530. The results of the research with the results of Yang et al. (2023) and Sun et al. (2023) is similar. The

confirmation of this hypothesis shows that Learning enables organizations to interact with the internal and external environment. From this interaction, knowledge about the changing environment, market and stakeholder demands is created, acquired, shared, integrated and used to increase organizational value. Learning provides an opportunity for the organization to actively generate information relevant to understanding and addressing the ever-changing economic, social and environmental demands of stakeholders simultaneously. The information obtained through learning is used in the pursuit of strategies and policies that address the demands of sustainability performance. SCL represents the sustainability-related knowledge of a learning process aimed at solving social, environmental and economic issues, which is necessary for the successful implementation of sustainability and performance among supply chain members. SCL creates competitive advantages and leads to improved sustainability performance of companies. Learning the supply chain in the manufacturing industry also helps to increase the company's long-term values and ultimately sustainability performance. Effective supply chain management encourages companies to adopt environmentally friendly approaches along with economic and social performance in sourcing, production and distribution processes. By incorporating sustainable practices into SCL, such as eco-design, green packaging, and renewable energy sources, organizations can achieve cost savings through reduced energy consumption, reduced waste, and improved resource efficiency. Finally, it increases the overall sustainability of their operations.

5.2 Managerial Implications

Enhancing Sustainability Performance in SMEs through GTI and SCL. To strengthen sustainability performance in SMEs through GTI and SCL, managers must implement a comprehensive and strategic approach. This approach should encompass four key pillars: 1) Development of a Green Innovation Culture, 2) Strengthening Collaboration with Suppliers, 3) Establishing Sustainable Performance Evaluation Systems, and 4) Utilizing Digital Technologies. 1) Development of a Green Innovation Culture: Managers should pay special attention to fostering an organizational culture that promotes green innovations. This involves encouraging employees to contribute creative ideas aimed at reducing environmental impacts. To facilitate this, organizing workshops and training sessions related to green technologies can enhance employees' awareness and skills. Additionally, establishing a reward system for innovative ideas can provide further motivation for employee participation. 2) Strengthening Collaboration with Suppliers: Managers should focus on building close and effective relationships with suppliers and supply chain partners. Such collaboration may involve forming joint working groups to exchange best practices and green technologies. For instance, regular meetings can be held to share successful experiences and discuss challenges and solutions. This type of collaboration not only aids in improving environmental performance but can also lead to cost reductions and

increased efficiency. 3) Establishing Sustainable Performance Evaluation Systems: Managers need to develop sustainable performance evaluation criteria that encompass environmental, social, and economic indicators. These criteria should be designed to enable the measurement of progress and facilitate data-driven decision-making. For example, utilizing performance management software can assist in data collection and analysis, helping managers identify strengths and weaknesses. 4) Utilizing Digital Technologies: The adoption of digital technologies such as the Internet of Things (IoT) and data analytics can contribute to process optimization and waste reduction. Managers should take the investment in these technologies seriously and design implementation plans accordingly. For instance, deploying smart sensors on production lines can help monitor energy consumption and raw material usage, leading to cost reductions and improved environmental performance.

6 CONCLUSION

The purpose of this article was to analyze the impact of GTI and SCL on sustainability performance in SMEs. For this purpose, first by collecting information on the theoretical foundations and literature of the subject, library sources, articles and scientific databases were used, and finally, the results were discussed by testing the proposed model in SMEs in Mobarakeh Industrial town in Iran. The findings showed the effect of GTI on sustainability performance. The effect of SCL on stability performance was also confirmed. The results showed that SCL has a greater impact on stability performance than GTI. In addition, the results showed that green product innovation from GTI and customer learning from SCL had the greatest impact on sustainability performance. Green process innovation from GTI and supplier learning from SCL had the least impact on sustainability performance.

Among the advantages of the proposed model of the current research, we can mention the comprehensiveness of the examined variables and the novelty of the research topic in the sense that the effect of GTI and SCL simultaneously affects SP. Overall, it can be stated that the implementation of GTI and SCL is essential for enhancing sustainability outcomes in small and medium-sized enterprises (SMEs). The sustainability of companies is critical to realizing an organization's vision without compromising its market advantage while meeting the needs of economic growth, and environmental and social responsibilities. The transition of an organization to a sustainable future should be realized through the efforts and responsibility of executive directors, stakeholders and employees.

While our initial discussion emphasized the benefits of GTI and SCL, such as enhanced sustainability, improved operational efficiency, and competitive advantage, we acknowledge that there are inherent challenges and costs that organizations may encounter during implementation. The primary concern related to GTI is the increase in operational costs, which can impose a significant financial burden on SMEs. The initial investment in green technologies involves purchasing advanced equipment, training personnel, and

integrating these technologies into existing processes. Although the long-term benefits and positive environmental impacts of GTI are considerable, the short-term costs may hinder organizations from adopting these initiatives. Additionally, implementing SCL practices comes with complex challenges. Transitioning to SCL may require significant adjustments in supplier relationships, transportation methods, and inventory management. For instance, sourcing materials from environmentally friendly suppliers can limit options and increase procurement costs. Moreover, the need for transparency in the supply chain can elevate administrative burdens and complexities associated with ensuring supplier compliance with sustainability standards. Resistance to change within organizations is another challenge; employees and stakeholders accustomed to traditional practices may be reluctant to embrace new technologies or processes. This resistance can lead to a lack of engagement or even active opposition, disrupting the successful implementation of these initiatives. Therefore, addressing this human factor and developing effective strategies for change management, such as promoting a sustainability culture and providing appropriate training, is essential. Finally, organizations must pay attention to the economic and regulatory context in which these innovations are implemented, as market fluctuations and political changes can significantly impact the success of their sustainability efforts.

A significant constraint of this study is the limited number of participants, which could hinder the ability to apply the results more broadly. A limited number of respondents can lead to statistical insignificance and may not adequately represent the broader population of SMEs. Additionally, the geographical focus on SMEs in Iran introduces further constraints; the unique economic, cultural, and regulatory contexts of this region may not reflect the experiences of SMEs in other countries. Consequently, caution should be exercised when extrapolating these findings to different settings. Another significant limitation is the reliance on self-reported data, which can introduce bias due to subjective perceptions and potential inaccuracies in responses. Self-reported measures are often influenced by social desirability and personal biases, potentially skewing the results. Furthermore, the timing of data collection during the winter of 2024 may also limit the applicability of findings to other periods, as external factors such as economic conditions and seasonal variations can impact business operations and attitudes toward innovation. Overall, these limitations highlight the need for further research with larger, more diverse samples and objective measures to validate and expand upon the current findings. Furthermore, the subsequent recommendations may be considered for upcoming studies:

1) Future investigations could explore the influence of various elements such as total quality management, hard and soft quality management, green supply chain management, green entrepreneurship and supply chain agility on sustainability performance in manufacturing and service organizations.

- 2) In future research, the effect of each dimension of GTI, i.e. green product innovation, green process innovation and end-of-line management innovation, on sustainability performance can be studied in three hypotheses.
- 3) In future research, the impact of GTI on the dimensions of sustainability performance, i.e. economic performance, social performance and environmental performance, can be studied in three hypotheses.
- 4) The current research can be studied among companies that are more related to green products and processes, such as food manufacturing industries.

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