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Sustainable supply chain practices and green HRM drive supply chain performance through green innovation

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Abstract

Purpose

This research seeks to investigate the effect of sustainable supply chain practices (SSCP) and green human resource management (green HRM) on supply chain performance. Besides, the paper examines the mediating role of green innovation in these relationships in the pharmaceutical sector.

Design/Methodology/Approach:

The researchers adopted a quantitative research strategy and used a structured questionnaire that was given to a purposive sample of 315 managers and senior staff of supply chain, operations, production, and environmental management departments of pharmaceutical firms in Jordan. The data gathered were analyzed by Structural Equation Modeling (SEM) to examine the proposed relationships and mediation effects.

Findings:

The outcomes showed that SSCP and green HRM both significantly positively effect supply chain performance. In addition, green innovation significantly mediates the effect of SSCP and green HRM on supply chain performance.

Research Limitations:

The focus of this research was on the manufacturing of pharmaceuticals in Jordan. Hence, the conclusions may not fully apply to other industries in different countries or sectors. In addition, the cross-sectional design limits the possibility of determining causal relationships.

Theoretical and Practical (Managerial) Implications:

On the theory part, this paper combines sustainable supply chain practices and green HRM into one model and confirms the mediating role of green innovation empirically, thus the paper contributes to the literature on sustainability and supply chain management. At the same time, the results offer managers a sound basis for environmental supply chain initiatives, supported by green HRM systems, to improve performance through green innovation.

Originality/Value:

By showing how the combined execution of SSCP and green HRM, through green innovation promotes supply chain performance, this research presents unique empirical proof from the pharmaceutical sector, thus making contributions to both sustainability and operational excellence.

1. Introduction

In the current global economy, the issue of environmental sustainability has elevated from being just one of the corporate social responsibility (CSR) activities to becoming a strategic necessity. Rapid industrialization and globalization have significantly worsened environmental degradation, thus provoking stakeholders—governments, consumers, and investors—to insist on eco-friendly practices by companies. Hence, this change is extremely important

in the pharmaceutical sector that is characterized by complex supply networks, high energy consumption, and the generation of chemically hazardous wastes that if not properly disposed of harm the environment (Al-Mdanat et al., 2026; Akwalu, 2024).

Pharmaceutical firms face a dilemma: producing high-quality, safe products while minimizing their environmental impact. To this end, a considerable number of enterprises have started to embrace Sustainable Supply Chain Practices (SSCP), which not only cover the environmental and social issues related to sourcing, manufacturing, and distribution but also go beyond the scope of traditional supply chain management. The use of technological means such as artificial intelligence and the application of digitization helps in carrying out such practices and also improving the overall supply chain performance (Chen et al., 2025). Nevertheless, relying on technology is not enough; the human aspect is equally important. Green Human Resource Management (GHRM) through green recruitment, training, and performance management carries the idea of employee alignment with environmental objectives and thus achieving an eco-conscious culture (Bindeeba et al., 2025).

Although the vital roles played by SSCP and GHRM in supply chain performance have been acknowledged, how they do so has not been sufficiently studied yet. Green innovation most simply refers to the innovation of environmentally friendly products, processes, or technologies, and it has been singled out as one of the chief mediators. It was revealed through research that GHRM raises green innovation, which becomes the connecting factor between a firm's dedication and the attainment of superior performance results through the full utilization of employee resourcefulness and problem-solving creativity (Bindeeba et al., 2025; Khan et al., 2023). Hence, the implementation of sustainable practices together with the development of a green-oriented workforce not only improves the overall performance directly; instead, it serves as an accelerator for innovation, which then becomes the main driving force behind the supply chain's efficiency and effectiveness.

This research aims to shed light on the pharmaceutical industry in Jordan, a pillar of the Jordanian economy and the largest exporter of pharmaceuticals in the Middle East and North Africa region. This sector faces a number of challenges, most notably water scarcity and the presence of pharmaceutical waste, which poses a risk if not properly managed. Therefore, it is necessary to take preventive measures (Al-Mdanat et al., 2026). On the one hand, Jordanian companies are adopting management practices that enhance efficiency; on the other hand, the lack of infrastructure and the incomplete application of Industry 4.0 technologies hinder the pushing of sustainability to its deeper levels (Al-Shboul et al., 2025). These circumstances would require the industry to innovate and embrace sustainable development to stay competitive.

Although sustainability has been globally acknowledged (United Nations, 2015; Office for government policy coordination, 2020), studies discussing the situation in developing economies and, more specifically, that of Jordan's pharmaceutical industry are still scarce. The majority of articles considers GHRM and SSCP as separate concepts and thus fail to explore how these "soft" human capital components work together with the "hard" operational strategies to bring about performance. Besides, there is hardly any paper that empirically investigates green innovation as a mediator between the sustainability initiatives and actual supply chain results. This article fills the voids by offering post-pandemic real-world data on the interrelations of SSCP, GHRM, and performance through green innovation, thus throwing the spotlight on how developing economies with limited resources can benefit from these strategies. In this study, we contribute to the existing literature by addressing the aforementioned gaps.

The major goal of this study is to examine the complex relationship between sustainable supply chain practices, green HRM, and supply chain performance, with green innovation as a mediating variable. Specifically, the study's goals were to: (1) examine the effect of sustainable supply chain practices and green HRM on green innovation; (2) investigate the effect of sustainable supply chain practices and green HRM on sustainable supply chain practices; and (3) test the

mediating role of green innovation in the relationship between sustainable supply chain practices, green HRM, and supply chain performance.

Theoretically, this research paper integrates sustainable supply chain practices and green human resource management into a single model, highlighting green innovation as the crucial mediator linking these practices to supply chain performance. Practically, the paper provides managers with research-backed guidance demonstrating how aligning sustainability-oriented supply chain and human resource initiatives can become a source of green innovation and a driver for improved overall supply chain performance.

2. Theoretical background and key concepts

2.1. Sustainable Supply Chain Management

To begin, it's essential to emphasize that the concept of Supply Chain Management (SSCM) is a comprehensive strategic concept that focuses on environmental and social factors, in addition to the traditional supply chain objectives of cost, quality, and delivery. As a strategic concept, it considers environmental and social factors alongside traditional supply chain objectives such as cost, quality, and delivery (Li et al., 2020; Aljawarneh et al., 2021). The concept of sustainable supply chain management is not limited to the economic performance; it extends to achieving environmental balance and individual well-being. Companies that integrate sustainability into their supply chains not only want to minimize the impact on the environment but also to increase their competitiveness and business continuity at the same time (Abegaz, 2024; Alkandi, 2025). In scientific studies, the concept of SSCM is mostly linked to its environmental aspect, as the demand to tackle problems like resource limitation, pollution, emission, and waste in supply chains is increasing rapidly. Environmental SSCM is not only dedicated to economic performance but also depicts the significance of ecological balance and the well-being of people by taking into account the entire supply chain from sourcing to disposal. Existing studies have reported that such practices may result in better environmental conditions, and, moreover, they may serve as key factors or mediators in the relationship between the sustainability initiatives and the overall business performance, including operational efficiency and financial outcomes (Wiredu et al., 2024; Khan et al., 2024).

Even if SSCM is basically composed of many different aspects, the current research limits itself to the operationalization of environmental SSCPs solely. By referring to former green supply chain studies, environmental SSCPs are evaluated with four practice-based dimensions: green purchasing, sustainable operations and production, green logistics and distribution, and internal environmental management. It is worth mentioning that these aforementioned dimensions illustrate the most vital methods in which firms make the environment central to their supply chains.

Green purchasing. This concept refers to the process of selecting and evaluating suppliers based on their environmental impact. It covers the acquisition of raw materials and inputs that are recyclable, environmentally friendly, or that have been produced with lower carbon emissions. Sustainable (Laghouag, 2023).

Sustainable operations and production. This refers to the extent to which industrial companies consider environmental factors and standards, in addition to their operational processes.. This aspect of the firm focuses on eco-efficiency, i.e., it is about producing more using less and generating less waste. Examples of practices are lowering energy usage, reducing harmful emissions to the minimum, streamlining the processes, and implementing lean production techniques that eliminate non-value-adding activities (Alkandi, 2025).

Green logistics and distribution focus on the environmental aspects of transportation, storage, and delivery of products. These practices, on the one hand, include optimizing transportation routes to reduce fuel consumption using environmentally friendly packaging materials; on the other hand, they are implementing reverse logistics systems that make product return, recycling, or safe disposal possible. Green logistics significantly contributes to the reduction of emissions and waste in the activities of downstream supply chain. (Laghouag, 2023)

Internal environmental management means the organizational structure that is mostly responsible for the initiation, as well as the perpetuation and progress, of the environmental supply chain initiatives. This idea implies a very high degree of management commitment, particularly when aligning environmental objectives with the company's policies, strategies, and culture. Conducting regular audits, providing necessary environmental training for employees to foster a strong environmental awareness, and implementing ISO 14001 standards are all expressions of environmental management (Taghavi, et al., 2020).

2.2. Green human resource management

Green Human Resource Management (GHRM) is the blending of environmental management principles with the traditional HR practices to encourage employees' sustainable behaviors, increase their environmental awareness, and gain their commitment to the organization's sustainability objectives (Yin, 2023). It is essentially a process of integrating environment-focused approaches to the major HR functions, i.e., recruitment, training, performance management, and reward system (Miao et al., 2023). The decision to switch to GHRM is an effort to build a workforce that embraces the green goals of the company, thereby improving both employee participation and the company's environmental performance (Chaudhary, 2019; Hameed et al., 2022).

This paper sees GHRM as a multidimensional concept and measures it along four dimensions: green recruitment and selection, green training and development, green performance management, and green compensation. Incorporating environmental aspects in recruitment not only ensures that the new hires resonate with the sustainability ethos (Adubor et al., 2022), but also that the human resource functions uphold these aspects consistently. Through training, employees get acquainted with their role in supporting green activities and minimizing the environmental footprint (Wulandari & Nawangsari, 2021). Besides evaluating the direct outcomes of the job, performance management in this context also looks at the environmental aspect, whereas reward focuses on incentivizing green behavior to make it more desirable and increase its rate of occurrence (Taamneh et al., 2025; Yong et al., 2020). Empirical evidence from several studies demonstrates that the implementation of these practices leads to positive effects on both environmental and organizational performances especially when there is a high level of dedication to sustainability (Shaikh et al., 2025; AlKetbi & Rice, 2024; Roscoe et al., 2019; Nson, 2023).

2.3. Supply chain Performance

Supply chain performance in pharmaceutical companies refers to the process of evaluating the various supply chain activities that contribute to operational reliability, regulatory compliance, product quality, plus the timely availability of the market. Considering the industry’s rigorous quality standards, high costs, and demand uncertainty, measuring performance is the key to achieving both operational excellence and patient safety (Boche et al., 2026; Kyeremeh et al., 2025). A comprehensive method of quantifying the pharmaceutical supply chain performance is to combine various metrics across different areas of the supply network. Jha et al. (2021) claim that a firm’s and its supply chain partners’ performance measurement system (PMS) should be the tool with which the strategic objectives and capabilities are aligned, thereby determining the significant dimensions of cost, quality, delivery, and customer satisfaction. This view goes along with Stewart’s (1995) statement that performance measurement has to be continuous and comprehensive across the supply chain to bring about real operational improvements.

Benchmarking is a typical method for pharmaceutical companies to evaluate supply chain performance by looking at their practices and results against the standards of the industry and the best competitors (Kyeremeh et al., 2025). Being able to look at performance across the entire system through a benchmarking lens not only makes firms aware of their areas of low performance but also empowers them to find IP ways for their improvement while at the same time running supply chains that are friendly to the environment (Akwalu et al., 2014).

Performance assessment frameworks also contribute to the impartial evaluation of pharmaceutical supply chains. Ming and Feng (2019) illustrate that the use of analytical methods such as the analytic hierarchy process (AHP) and data envelopment analysis (DEA) can help in pinpointing the proper performance indicators as well as assessing the level of efficiency in operations. On the other hand, Gunasekaran et al. (2001) point out that clearly defined performance metrics lead to enhanced competitiveness, customer service, and profits in supply chains. These kinds of methods can be supplemented by internal benchmarking methods, including performance value analysis and SWOT analysis, which assist pharma companies in analyzing their internal capabilities and weaknesses so as to attain more stable performance among the various supply chain functions (Soni & Kodali, 2010). Working together with supply chain partners is essential to supply chain performance in the pharmaceutical industry. Simatupang and Sridharan (2004) point out that coordinated activities and information sharing, especially at the strategic level, significantly improve supply chain performance. They also stress that supply chain performance is not only about the internal operations of a company. On top of that, drug manufacturers are giving more weight to environment/sustainability aspects in their performance metrics as regulators and other stakeholders are demanding eco-friendly supply chains that are still efficient (Shaw et al., 2010). Supply chain performance has been operationally defined as the degree to which pharmaceutical companies align their supply chain activities with the three-pillar sustainability framework of economic efficiency, environmental responsibility, and social compliance.

2.4. Green Innovation

Green innovation is generally understood as a set of environmentally friendly product and process development and implementation initiatives that limit the negative impacts on the environment and at the same time improve the performance of organizations from the standpoint of sustainability (Huang & Li, 2017). It includes two aspects: green product innovation, such as producing products using materials that are good for the environment, cutting down energy consumption, and making products easier to recycle, and green process innovation, which is about changing production methods in order to reduce the release of harmful substances, the creation of waste, and the consumption of resources. In practice, a green innovation scale developed by Chen et al. (2006) is used. It consists of seven items which reflect the extent, to which an organization introduces eco-friendly products, saves on material and energy, prevents polluting and waste-producing activities, and increases the overall environmental efficiency of production processes (Naz et al., 2023).

In a supply chain that is sustainable, green innovation is an important aspect that can be leveraged by companies to improve resource efficiency, meet environmental standards, and cut down on costs thus further enhancing the performance of the entire supply chain (Al-Khatib, 2022). The previous studies conducted on the issue show that firms engaging in higher levels of green innovation not only outperform their competitors in terms of environmental and production benefits, since green innovations provide the basis for cleaner production, cost savings, and better collaboration among supply chain partners (Chen et al., 2007; Fernando et al., 2019).

2.5. Hypotheses development

2. 5.1. Sustainable Supply Chain Practices, Green HRM, and Green Innovation

Among other things, environmentally friendly supply chain practices can be a great leverage of green innovation. They do this partly by motivating the usage of eco-friendly raw materials, technologies, and procedures. Besides, green purchasing deepens the collaboration with the suppliers, which in turn stimulates green product and process innovations, and eventually contributes to resource efficiency improvement and waste reduction (Wang & Liu, 2022; Gelagay & Werke, 2024). Also, a firm that installs an environmental management system will be better able to innovate by focusing sustainability and corporate social responsibility (CSR) initiatives equally and by using the environmental management system as a bridge between the adoption of green supply chain management (GSCM) practices and green innovation (Jell-Ojobor & Raha, 2022). Internal environmental actions also help to create a sustainability-oriented work culture that is the source of continuous development and ecological innovation (Liao & Yang, 2023). In other words, companies that implement green supply chain practices have the potential to innovate more in the environmental sector.

Green Human Resource Management (GHRM) is a practice of aligning HR strategies and operations with the environmental goals. It covers green recruitment, training, performance management, and employee involvement, etc., as the main features of such human resource practices. These activities enhance employees' environmental awareness, skills, and motivation, which are vital contributors to creativity and green innovation (Song et al., 2020; Hendarjanti, 2022). Studies based on data reveal that companies that implement GHRM are more likely to come up with eco-friendly products and processes, as their staff members not only use green knowledge but they also exhibit eco-friendly behaviors (Singh et al., 2020; Faizan et al., 2023). Besides that, a well-structured GHRM system contributes to creating a sustainability-oriented culture which, in turn, increases the company's ability to innovate and improves its environmental performance (Altassan, 2024; Zhang et al., 2024; Gazi et al., 2025). Consequently, the following hypotheses are proposed:

H1

Sustainable supply chain practices (SSCP) has significant positive effects on green Innovation.

H2

Green human resource management (GHRM) has a significant positive effects on green Innovation.

2.5. 2. Sustainable Supply Chain Practices, Green HRM, and Supply Chain Performance.

Implementing sustainable supply chain practices is essentially one of the main factors that can lead to improved supply chain performance not only environmentally but also economically and socially. Green Supply Chain Management (GSCM) practices like green logistics and eco-design bring about decreased costs of operations as well as a better economic performance that comes through efficient use of resources and less generation of waste (Nureen et al., 2023). For example, companies that have implemented green logistics will reduce the emissions coming from their transportation operations, use less fuel, and thus save on the costs of their transportation, which could result in higher profitability while continuing to support environmental goals (Ali, 2022). Moreover, going green in the supply chains leads to social responsibility, which has an effect on the local community as well as the relationship with stakeholders (Habib et al., 2021). Green supply chain integration is linearly related to social performance, a fact that a detailed study has revealed, which means that organizations that go green in this way improve their image towards customers and hence enjoy customer loyalty (Çankaya & Sezen, 2019). According to the findings, the adoption of green initiatives inherently aligns with the broad goals of sustainable development, which, in turn, support social equity and community welfare (Karaman et al., 2024).

Sustainable supply chain practices from a larger perspective also mean that the provision of environmental laws is part of the package that ultimately results in better organizational performance. Firms that are known for their green activities can be considered to have a competitive advantage since, on one hand they fulfill the requirements of the regulations and on the other, they attract consumers who are environmentally conscious (Han & Huo, 2020; Murad & Shu-li, 2023). Besides that, the results imply that companies' compliance with green practices is translated into actual environmental benefits such as a decrease in the level of carbon emissions and better waste management, which altogether lead to the reduction of ecological footprints (Ali, 2022; Mushtaq, 2023). All these, in turn, are consistent with organizations' goals of achieving sustainability in the long run as demonstrated by their capability of fulfilling the United Nations Sustainable Development Goals (SDGs) through their supply chain initiatives (Labaran & Masood, 2023).

In pharmaceutical industries, Green Human Resource Management (GHRM) is one of the ways by which supply chain performance (SCP) can be improved. This is by GHRM influencing employees to engage in environmentally responsible behaviors while at the same time helping to comply with the strict regulatory and quality standards. GHRM increases employees' pro-environmental behavior and their level of commitment, thus leading to better operational efficiency, less waste, and more environmentally compliant supply chain processes (Chaudhary, 2019; Acquah et al., 2020; Gelagay & Werke, 2024). Green training, competency development, and green motivation are the key elements that bring about green innovation and sustainable practices, which in turn are the ingredients of strong and efficient pharmaceutical supply chains (Yafı et al., 2021; Jawaad et al., 2022;). GHRM's alignment with Green Supply Chain Management (GSCM) will also push forward the environmental collaboration amongst the supply chain partners and thus lead to improved operational and financial performance (Agyabeng-Mensah et al., 2020; Dede, 2019). Based on these insights, we prop[ose the following hypothesis:

H3

Sustainable supply chain practices (SSCP) significantly positively effects supply chain Performance.

H4

Green human resource management positively effects supply chain performance in pharmaceutical firms.

Green innovation is a key element that helps not only to enhance supply chain performance by making operations more efficient, profitable, and environmentally sustainable but also to respond to the escalating regulatory and environmental pressures. Studies based on real-world data indicate green innovation leads to enhanced green supply chain and overall business performance mainly via developing new capabilities and systematic implementation (Al-Khatib, 2022; Novitasari & Agustia, 2021). It also goes hand-in-hand with getting market and financial gains, as it is a way of making good returns while, at the same time, solving environmental problems (Rodríguez-González et al., 2022). In addition to this, the technological advances that green innovation entails, such as big data analytics, help increase the supply chains' responsiveness and efficiency (Jum'a et al., 2023; Xu & Zhao, 2022). Nevertheless, the realization of such advantages depends on the extent to which green supply chain management (GSCM) practices and corporate social responsibility (CSR) can mediate the process (Khaksar et al., 2016; Handayani et al., 2017), and they might, therefore, be preceded by short-term financial difficulties as a result of high initial investment costs (Agyabeng-Mensah et al., 2023). Based on the above discussion, the research hypothesis for us will be as follows:

H5

Green Innovation has a significant positive effects on supply chain performance.

2.5.3. The Mediating Role of Green Innovation

In pharmaceutical companies, green innovation plays a pivotal role as a key intermediary mechanism through which sustainable supply chain practices (SSCP) and green human resource management (GHRM) contribute to improved SCP performance. Because pharmaceutical companies are subject to strict regulations and are deeply concerned about the environment, sustainability practices must always be translated into tangible innovations, such as environmentally friendly processes, green packaging, and cleaner logistics, to achieve performance gains.

While giving the operational basis, and GHRM, employees' environmental competencies and innovative behaviors, their effect on performance is mostly indirect, and green innovation is largely the channel through which the performance impact becomes real (Wang & Liu, 2022; Gelagay et al., 2023). There have been experiments lately to figure out the impacts of GHRM on green innovation. One of the results was that green innovation serves as a mediator between green HRM and organizational performance (Abbas et al., 2023; Singh et al., 2024; Fang et al., 2022). For environmentally sensitive pharmaceutical supply chains, a program like this can be used by the firms to successfully turn sustainability programs into supply chains that are both resilient and high-performing. Thus, the overall supply chain performance is improved (Altassan, 2024; Rafiq & Weichao, 2025; Gazi et al., 2025; Abedelrahim et al., 2024). In the case of pharmaceutical supply chains, which are environmentally sensitive, this kind of scheme helps firms to transform sustainability programs into supply chains that are both resilient and high-performing; hence, the overall supply chain performance is enhanced (Altassan, 2024; Gazi et al., 2025; Abedelrahim et al., 2024). Based on the above, we form our last two indirect hypotheses as follow:

H6

Green Innovation significantly mediates the relationship between sustainable supply chain practices (SSCP) and supply chain performance.

H7

Green Innovation significantly mediates the relationship between green human resource management (GHRM) and Supply Chain Performance.

3. Methodology

The study is primarily focused on a quantitative method to explore the interrelations among research areas (Fig. 1), thereby enabling the empirical evaluation of hypothetical relationships through statistical analysis.

3.1. Sampling Design

The study aligning the research objectives with the empirical setting, particularly focuses on pharmaceutical manufacturing companies in Jordan that is a mature industry supplying both the local and export markets. The industry as defined by the Jordan Food & Drug Administration (JFDA, 2025) includes approximately 40 licensed manufacturers that mainly produce generic and branded medicines, bulk drugs, along with active pharmaceutical ingredients (APIs). The intended participants are managers and senior staff from various departments such as supply chain, operations, production, quality, sustainability, or environmental management since they are the ones directly knowledgeable of sustainable supply chain practices, green innovation activities, and associated performance results. Purposive sampling was used to choose those respondents with relevant knowledge and decision-making authority to increase the reliability of data, which is consistent with pharmaceutical research (Belal et al., 2025; Mustafi et al., 2024). To achieve enough statistical power for Structural Equation Modeling (SEM) and mediation analysis, the

researcher distributed 340 questionnaires. 315 valid responses were returned, which not only met but also exceeded the minimum sample size required for SEM and mediation analysis, thus providing enough statistical power (Hair et al., 2022). The questionnaires were distributed in proportion among the 40 companies, with each company contributing about 6–8 qualified respondents. Hence, the proportional distribution increased the representation of organizations and lowered the chances of a single-informant bias.

3.2. Questionnaire Design

Data for this study has been collected using a structured questionnaire, which is widely recognized as an effective tool for examining perceptions and practices related to sustainable supply chain management in the pharmaceutical sector (Belal et al., 2025; Mustafi et al., 2024). Before the questionnaire was finalized, it underwent an extensive pre-testing phase to confirm that it was understood and was appropriate for the purpose it intended to serve. This exercise was done by a two-fold method: at first, seven independent researchers checked the draft to ensure that the language and the constructs used were in line with the research standards and that the document properly and accurately measured the desired variables. Further changes were made based on the pilot test, which involved fifteen respondents from the target group. The pilot test offers a deeper understanding of the practical side of the questionnaire, such as the ease of understanding the content and its relevance to the respondents. The pilot testing comments led to a couple of specific changes that made the questionnaire clearer and easier to fill out by the respondents. The questionnaire was divided into five parts. The first part covered demographic variables, including gender, age, job title, educational level, and years of experience. The second part pertained to participants' perception of the supply chain practices scale that is adopted from previous research (Zhu and Sarkis 2004), which included twelve items, for example, “Our firm selects suppliers based on their environmental performance. *Our firm actively works to reduce waste generated.*" *Our firm has clear environmental policies guiding supply chain activities*. The third part is the scale of green HRM with ten items adopted from Renwick et al. (2013) and Dubey et al. (2022), covering green recruitment and selection, training, performance management, and compensation; as an example, “Environmental criteria are considered when recruiting new employees. The fourth part entails a green innovation scale of seven items as referenced in Chen et al. (2006) and Martinez-Rose & Lebeaga (2009); for example, “*Our firm regularly develops new products or services that reduce environmental impact*" and “*Our company actively implements new technologies that enhance environmental sustainability*”. The final part is the supply chain performance scale, which is operationalized as a construct derived from three dimensions: environmental performance, economic performance, and social performance. The scale is composed of nine items adopted from Kumar et al. (2023), Li et al. (2020) and Mousa et al. (2025), three for each one; for example, “*Our firm has reduced environmental pollution resulting from supply chain activities.*" We distributed 340 questionnaires to participants at the selected pharmaceutical manufacturing firms. After follow-up, we collected 315 usable responses, a 92% response rate. Table 1 shows the descriptive statistics of the demographic variables:

Table 1
Demographic Characteristics of the Respondents (N = 315)

Variable	Category	Frequency	Percentage (%)
Gender	Male	200	63.5
	Female	115	36.5
Age	30 years and below	80	25.4
	31–40 years	110	34.9
	41–50 years	98	31.1
	Above 50 years	27	8.6
Job title	Supply Chain & Logistics Managers	60	19.0
	Operations & Production Managers	83	26.3
	Quality &Compliance Managers	68	21.6
	Sustainability / Environmental / HSE Managers	70	22.2
	Senior Executives (Directors / Heads / COO)	34	10.8
Education	Bachelor's Degree	190	60.3
	Master's Degree	110	34.9
	PhD	15	4.8
Years of Experience	5 years and below	62	19.7
	5–10 years	92	29.2
	11–15 years	75	23.8
	15 and above	86	27.3

Table 1 depicts the demographic characteristics of the 315 respondents. Most respondents were males (63.5%), and the females made up 36.5% of the sample. From the age perspective, the majority of the participants were within the 31, 40 years (34.9%) and 41, 50 years (31.1%) categories, thus showing a mature and professionally experienced workforce. In terms of job titles, Operations & Production Managers formed the biggest group (26.3%), followed by Sustainability/Environmental/HSE Managers (22.2%) and Quality & Compliance Managers (21.6%), thus the key functional areas related to supply chain and environmental management got their fair representation. Most of the respondents were holders of a Bachelor's degree (60.3%), compared to 34.9% who had a Master's degree which reflects a well-educated sample. With regard to professional experience, the largest number had more than 10 years of experience (51.1%), hence the registered data represent experienced professionals who know their stuff and are able to provide the accurate insights.

4. Data analysis and results

Data Analysis

The authors used Smart PLS 4.0 software in their study. This is a great and well-known tool for partial least squares structural equation modeling (PLS-SEM) (Hair et al. 2019). Smart PLS fits very well to complex models having several constructs and indicators because, among other things, it allows a combined evaluation of measurement and

structural models, and it can handle small to medium sample sizes and data that are not normally distributed (Hair et al. 2019; Ringle et al. 2020). The procedure comprised a review of the measurement model, structural model, and assessment of the possibility of a common method bias. PLS-SEM was chosen over the other methodologies as it is capable of handling models with multiple mediating relationships and is appropriate for research with small to medium sample sizes (Hair et al. 2019). In contrast to Covariance-Based SEM (CB-SEM), PLS-SEM is not dependent on strict normality assumptions and is more geared towards exploratory and theory-building research. The procedure comprised a review of the measurement model, structural model, and assessment of the possibility of a common method bias. PLS-SEM was chosen over the other methodologies as it is capable of handling models with multiple mediating relationships and is appropriate for research with small to medium sample sizes (Hair et al. 2019). In contrast to Covariance-Based SEM (CB-SEM), PLSSEM is not dependent on strict normality assumptions and is more geared toward exploratory and theory-building research.

Measurement Model

The measurement model was assessed in terms of internal consistency, convergent validity, and discriminant validity. The use of Cronbach's alpha (α) and composite reliability (CR) has confirmed the reliability; all the constructs, in fact, exceeded the recommended threshold of 0.70 according to Hair et al. (2019). Convergent validity was demonstrated since the average variance extracted (AVE) for all constructs was greater than 0.5 Majority of the outer loadings of the indicators were above 0.70 (Hair et al., 2019). Reliability and validity of constructs are shown in the Table (1).

Table (2) Construct reliability and validity.

Constructs	Cronbach's alpha	Composite reliability (rho_a)	Average variance extracted (AVE)
Economic Performance	0.820	0.835	0.742
Environmental Performance	0.772	0.780	0.686
Green HRM	0.922	0.923	0.588
Green Innovation	0.919	0.921	0.674
Green Logistics & Distribution	0.794	0.806	0.708
Green Purchasing	0.734	0.750	0.653
Interna Environmental Management	0.825	0.830	0.740
Social Performance	0.796	0.816	0.714
Supply Chain Performance	0.871	0.896	0.512
Sustainable Operation & Production	0.752	0.758	0.670
Sustainable Supply Chain Practices	0.807	0.820	0.345

Discriminant validity was evaluated by calculating the Heterotrait-monotrait ratio (HTMT) (according to Henseler et al., 2015) and the. Table (3) shows HTMT values were below the threshold of 0.85 for all constructs, indicating excellent discriminant validity. These results demonstrate that the constructs are distinct and measure unique aspects of the study's conceptual framework.

Table (3) Heterotrait- monotrait ratio (HTMT) - Matrix											
Construct	**EP**	**EP**	**GHRM**	**GI**	**GL&D**	**GP**	**IEM**	**SP**	**SCP**	**SO&P**	**SSCP**
Economic Performance											
Environmental Performance	0.438										
Green HRM	0.415	0.445									
Green Innovation	0.455	0.542	0.493								
Green Logistics & Distribution	0.517	0.547	0.535	0.612							
Green Purchasing	0.467	0.514	0.555	0.553	0.610						
Interna Environmental Manaegment	0.276	0.212	0.261	0.261	0.236	0.262					
Social Performance	1.131	0.446	0.389	0.447	0.491	0.426	0.266				
Supply Chain Performance	1.077	0.823	0.477	0.551	0.594	0.538	0.289	0.540			
Sustainable Operation & Production	0.558	0.572	0.447	0.542	0.561	0.540	0.300	0.541	0.639		
Sustainable Supply Chain Practices	0.630	0.629	0.603	0.662	0.511	0.547	0.759	0.599	0.711	0.563	

Common Bias Method (CMB) and Model Fit

The model fit was checked by standardized root mean square residual (SRMR), which is a popular one of the criteria for checking the goodness of the fit of PLS-SEM. The SRMR value of your model was 0.017, which is less than the required level of 0.08 (Hu and Bentler 1999). Such value shows a good enough fit between the presumed model and the actual data; thus, your model is able to correctly depict the relations among the constructs.

Structural Model

The structural model was analyzed with PLS-SEM utilizing bootstrapping of 5000 resamples in order to verify the relationships between constructs. Path coefficients (β) (Fig. 2) and t-values (Fig. 3) were studied to check the significance of the hypothesis valid relationships. The R2 values of the Supply Chain Performance (0.382) and Green Innovation (0.376) refer to the part of the variance that is explained by the respective models (Hair et al. 2019). The data, therefore, seem to indicate that the constructs together account for a moderate share of the variations in the dependent variables. In addition, the Q2 values, a measure of the prediction quality of the model (Stone 1974), are all positive, which gives even more evidence that the model is valid and that it has the ability to accurately predict the results. Hence the model's explanatory power concerning the relationships among the constructs and its prediction power are backed up by these results.**Figure 2: Results of the structural model analysis**

The results are summarized in Table (4). The results show that Sustainable Supply Chain Practices significantly influences Green innovation (β = 0.482, t = 10.666, p = 0.000) and Supply Chain performance (β = 0.439, t = 7.677, p = 0.000). The relationship between Green HRM and Green Innovation and Supply Chain performance were significant (β = 0.201, t = 3.810, p = 0.000) (β = 0.103, t = 1.97, p = 0.001) respectively. Green innovation positively impacts Supply Chain performance (β = 0.168, t = 3.166, p = 0.002). The analysis further reveals that Green innovation positively mediates the relationship between Sustainable Supply Chain Practices and Supply Chain performance (β = 0.081, t = 3.003, p = 0.003) and mediates the relationship between the Green HRM and the supply chain Performance (β = 0.034 t = 2.338, p = 0.019).

Table 4
Hypotheses testing for direct and indirect effects

H1	**Hypothesis**	**Original sample (O)**	**T statistics (|O/STDEV|)**	**P values**
	Sustainable Supply Chain Practices -> Green Innovation	**0.482**	**10.666**	**0.000**
H2	Green HRM -> Green Innovation	0.201	3.810	0.000
H3	Sustainable Supply Chain Practices -> Supply Chain Performance	0.439	7.677	0.000
H4	Green HRM -> Supply Chain Performance	0.103	1.97	0.010
H5	Green Innovation -> Supply Chain Performance	0.168	3.166	0.002

H6	**Mediation results**			
	Sustainable Supply Chain Practices -> Green Innovation -> Supply Chain Performance	**0.081**	**3.002**	**0.003**
H7	Green HRM -> Green Innovation -> Supply Chain Performance	0.034	2.338	0.019

4. Discussion

This research is focused on how Sustainable Supply Chain Practices (SSCP) and Green Human Resource Management (Green HRM) could affect the Supply Chain Performance (SCP) of pharmaceutical companies in Jordan, also considering Green Innovation (GI) as a mediator. The results have strongly confirmed the hypothesized links and have given quite a few practical as well as theoretical insights. First, Sustainable Supply Chain Practices significantly influence Green Innovation (β = 0.482, p < 0.001), representing one of the strongest relationships in the model. That is to say, sustainable supply chain strategies are like a nourishing ground for innovation. So, they might lead to collaboration with environmentally friendly suppliers, the use of eco-technologies, and even doing environmental improvements as a habit. In the case of Jordan, this finding is in agreement with the research of Almajali (2021). Secondly, the result reveals that Green HRM has a positive impact on Green Innovation (β = 0.201, p < 0.001). The evidence points to the fact that environmentally focused human resource practices, for example, green recruitment, environmental training, performance appraisal, and reward systems, allow employees to become more aware, skilled, and motivated to participate in creative environmentally friendly actions. Considering the condition of the pharmaceutical companies in Jordan, where the governmental and societal focus on environmental standards is increasing, adopting green HRM will most probably be the source of green product, process, and technology innovations. Third, in addition to the above, the study findings also show that sustainable supply chain practices have the most substantial direct impact on supply chain performance (β = 0.439, p < 0.001). In other words, this points out

that environmentally responsible procurement, green logistics, supplier collaboration, and reverse logistics are the main factors leading to improved performance outcomes. Pharmaceutical companies, which are very much dependent on imported raw materials and are under the impression of very stringent quality standards, thus believe sustainable supply chain integration is the way to go for successful operations. In the pharmaceutical industry's case in Jordan, the research work finding of Almasarweh (2022) corresponds to our study. Fourthly, green HRM also has a positive direct impact on supply chain performance (β = 0.103, p = 0.010), although the effect size is rather small. The integration of human resource policies with environmental objectives leads to the efficient, responsive, and sustainable performance of the supply chain. Nevertheless, the relatively tiny coefficient compared to the other paths indicates that green HRM may have a significantly larger indirect impact through innovation than through a direct effect only. Fifth, green innovation positively influences supply chain performance and is the most significant factor in enhancing supply chain performance (β = 0.168, p = 0.002). This evidence shows that pharmaceutical companies producing eco-friendly product designs, using cleaner production technologies, and carrying out waste-reduction processes can expect to see their supply chain efficiency, flexibility, and performance, in general, increase. Given that the pharmaceutical industry in Jordan is highly regulated and that quality is of utmost importance, green innovation is the resource that can help reduce costs, increase compliance, and solidify the competitive position.

In the mediation analysis part, the findings reveal that green innovation partly mediates the effect of green HRM on supply chain performance (β = 0.034, p = 0.019). This means that green HRM improves supply chain performance not only directly but also indirectly through hybrid green innovation. Green innovation also partially mediates the relationship between sustainable supply chain practices and supply chain performance (β = 0.081, p = 0.003). The higher indirect effect in this path reveals that the implementation of sustainable supply chain activities leads to improved performance mainly when they are associated with the generation of innovation. The findings, in general, corroborate the resource-based view (RBV) and dynamic capabilities perspectives that emphasize the role of internal capabilities (such as Green HRM) and external sustainability practices (such as SSCP) in the creation of competitive advantage through their conversion into innovative outcomes. In the pharmaceutical sector in Jordan, Green Innovation acts as a strategic mechanism that converts sustainability-oriented practices into tangible supply chain performance improvements.

5. Theoretical Implications

The current research bags the support of the Resource-Based View (RBV) as well as the Natural Resource-Based View (NRBV) by showing that Sustainable Supply Chain Practices and Green HRM are two key resources that help increase supply chain performance. Green innovation's positive mediating effect explains the way environmental practices lead to operational results. Besides that, through its focus on pharmaceutical companies in Jordan, the study takes the sustainability and performance discussion to the context of a less-developed country that has not been researched enough, and thus, it supports the generalizability of green capability theory not only in developed economies but also in the case of developing ones.

.6. **Practical Implications**

Managers should make sustainable supply chain practices and green HRM a part of their core strategy instead of considering them as mere tools for compliance. Green innovation can be triggered through methods such as environmental training, green recruitment, supplier collaboration, and eco-design, and these methods can also enhance the supply chain's performance. By setting environmental standards and providing innovation incentives to the pharmaceutical sector, the government of Jordan can help this sector become more competitive.

7. Limitations and future research

A cross-sectional design restricts the ability to determine cause and effect. The research is sector-specific and country-centric; hence, the results may not be easily generalizable. Besides that, the use of self-reported and perceptual performance measures might result in bias. Longitudinal designs should be used by future research, along with an emphasis on objective performance indicators and checking for more mediators or moderators (such as regulatory pressure, digitalization, and organizational culture). Comparative studies among industries or countries would also increase external validity.

Anonymity and confidentiality the identities of the informants and the firms that they represent were confidential and anonymous through- out the research process. Information that could potentially identify the participants was removed or disguised in the research outputs. The response transcripts and data logs were stored systematically and securely to protect the confidentiality of the participants. Thus, participants were notified that anonymity and confidentiality resulting in reports and publications would be maintained as the participants granted such consent.

Declarations

Ethics approval

The study protocol was reviewed and approved by the Institutional Review Board (IRB) at the Deanship of Scientific Research, Al al-Bayt University, Jordan, under Approval No. 30, dated 9 August 2026.

Ethical accordance:

The study was conducted in accordance with the ethical requirements of the Institutional Review Board at Al al-Bayt University and the principles of the Declaration of Helsinki. Participation was voluntary, informed consent was obtained from all participants, and their anonymity and confidentiality were protected throughout the study.

Consent to participate

Informed consent was obtained from all participants involved in the study. Before completing the questionnaire, participants were informed about the purpose of the study, the voluntary nature of their participation, their right to withdraw at any time without penalty, and the confidentiality and anonymity of their responses.

Consent to Publish

Not applicable. This study does not contain any individual person’s data or identifiable information requiring consent for publication.

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Author Contribution

A.B. and C.D. contributed to the conceptualization and design of the study. A.B. developed the methodology, conducted the data analysis, and prepared the initial manuscript draft. C.D. contributed to the literature review, interpretation of results, and manuscript revision. E. provided critical feedback and assisted with validation of the findings. All authors reviewed, edited, and approved the final version of the manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

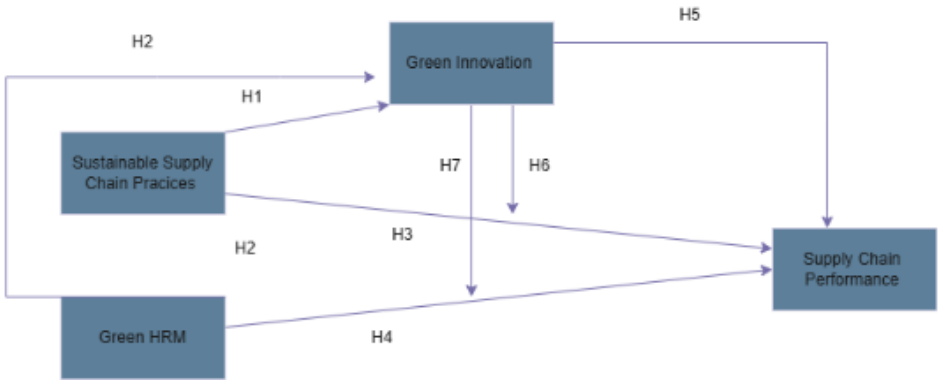


Figure 1

The proposed research model

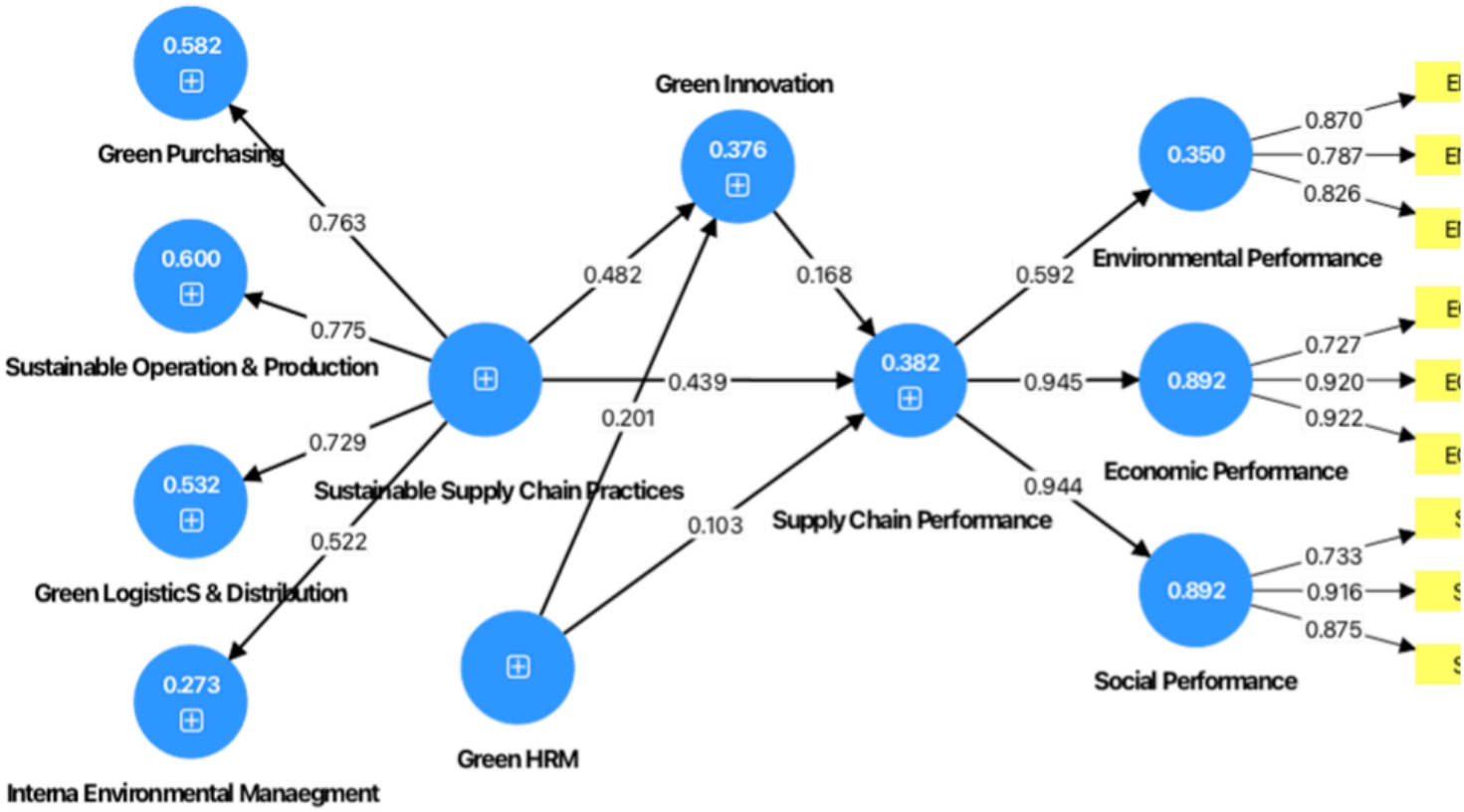


Figure 2

Results of the structural model analysis

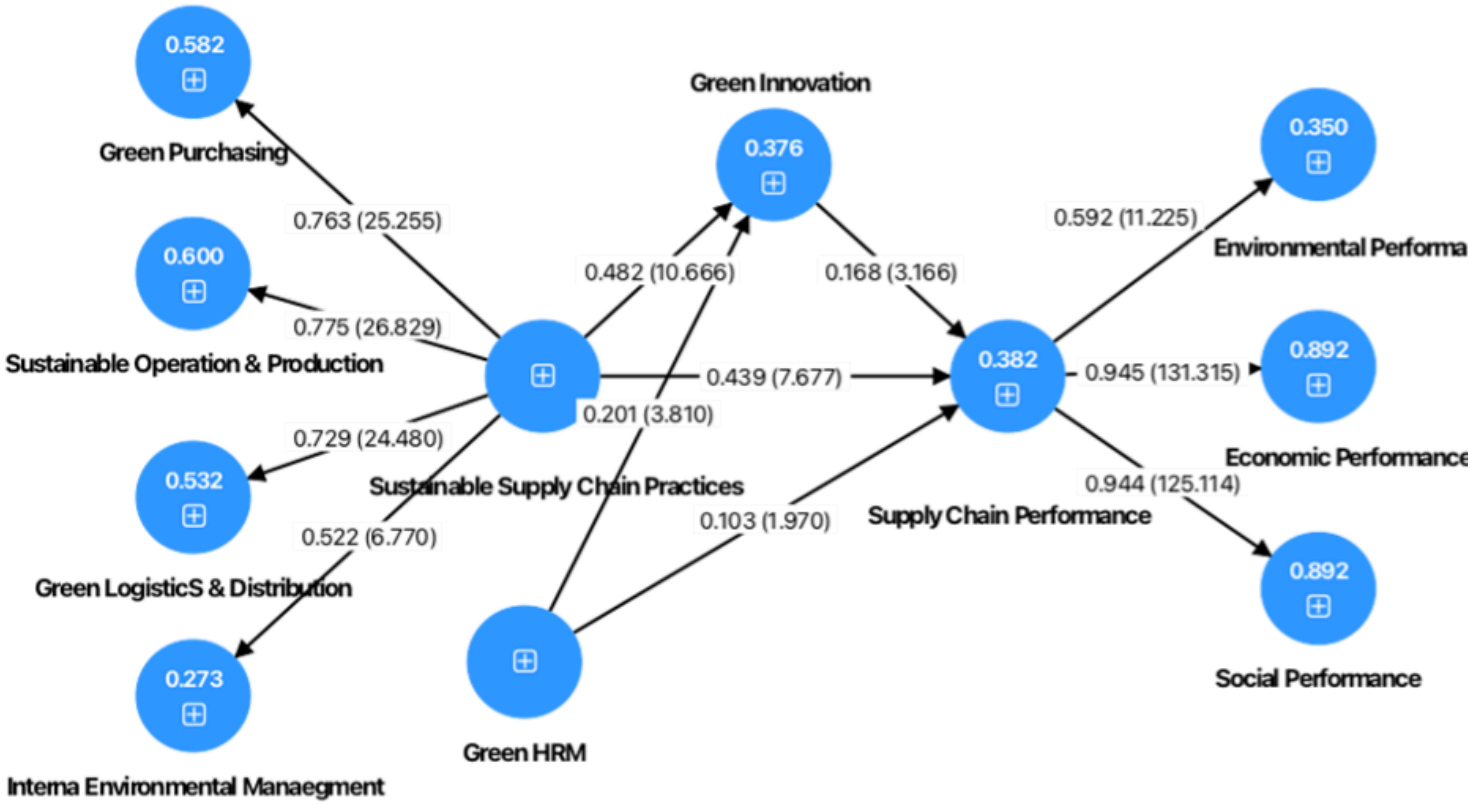


Figure 3

PLS-SEM Bootstrapping results for the proposed research model