

Green product innovation: influences on environmental sustainability performance

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Abstract

Purpose – In the contemporary era, practices that are not sustainable pose risks to both businesses and the environment. Thus, this study explores the interplay between workforce agility, knowledge sharing and product innovation flexibility and their collective impact on driving green product innovation and environmental sustainability.

Design/methodology/approach – Data were collected from 448 managers in the industrial sector to explore how workforce agility facilitates the exchange of critical information with customers and suppliers, thereby fostering collaborative innovation and the development of environmentally friendly products.

Findings – The study reveals a synergistic relationship where workforce agility enhances knowledge sharing, which in turn significantly contributes to green product innovation. This innovation, fostered through collaborative efforts and adaptable product development processes, is crucial for advancing a company's environmental sustainability performance.

Practical implications – This study emphasizes the importance of workforce agility and robust knowledge-sharing practices for enhancing environmental sustainability. Firms that invest in adaptable employees and foster open communication with stakeholders can drive sustainable innovation and adapt swiftly to market changes. These strategies enable organizations to meet evolving sustainability demands effectively, strengthening their competitive position.

Originality/value – This study highlights the crucial roles of knowledge sharing and flexible product development in driving sustainable innovation. It provides actionable insights for organizations, underscoring the need to integrate workforce agility and collaborative knowledge sharing as strategies for achieving sustainable business practices and enhancing environmental sustainability.

Keywords Environmental sustainability, Green business practices, Workforce agility, Knowledge sharing, Sustainable product innovation

Paper type Research paper

1. Introduction

In an era where unsustainable practices threaten the viability of businesses and the environment alike, the imperative for firms to integrate sustainability into their strategic framework has never been more pressing. This paper explores the complexities of today's dynamic business environment, echoing the sentiments of [Moussa *et al.* \(2020\)](#) and [Saeed and Kersten \(2020\)](#) on the need to adopt a holistic sustainability approach at all levels of the organization. Our study extends this discourse by shedding light on the transformative role of sustainable green product innovation as a key driver in enhancing both ecological and social performance, thereby sustaining a competitive edge and contributing to a better societal and environmental future. This approach not only generates value for all stakeholders but also helps mitigate adverse environmental impacts, enabling companies to enhance their ecological and social performance and, as a result, sustain their competitive advantage and also contribute to a better future for society and the environment ([Abbas and Khan, 2023](#); [Moussa *et al.*, 2020](#); [Saeed and Kersten, 2020](#)).

In this environmentally conscious world, sustainable green product innovation emerges as a crucial variable in promoting sustainable growth and mitigating environmental impacts.



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Today's organizations are under mounting pressure to foster green innovations – these are the development of products, processes, and technologies that minimize environmental harm while maximizing efficiency (Obeidat *et al.*, 2020). Consequently, embedding green innovation practices within a firm's strategic planning and operations has become essential (Abbas and Khan, 2023; Shahzad *et al.*, 2020). In this study, we place particular emphasis on sustainable green product innovation as the main variable, seeking to explore its determinants and potential to further drive environmentally sustainable performance.

This underscores the critical importance of integrating sustainable business practices into organizational decision-making. Gains in environmental sustainability are achieved when organizations adapt their operations to minimize environmental impacts such as carbon dioxide and methane emissions, chemical pollutants, excessive packaging, and waste (Junaid *et al.*, 2022). Achieving these sustainability goals involves implementing exemplary management practices, actively engaging suppliers and customers in green product development, and leveraging advanced technological capabilities and unique competencies (Zhao *et al.*, 2018; Zameer *et al.*, 2019).

By doing so, organizations can elevate their level of environmental sustainability, creating a harmonious synergy between economic growth and ecological preservation. Green innovation is manifested in various forms, including renewable energy technologies, sustainable building materials, and eco-friendly products. When organizations adopt these green strategies, they are capable of reducing energy consumption, diminishing waste and pollution, and safeguarding natural resources, all while enhancing their financial performance (Chen *et al.*, 2006). Moreover, green innovation can provide a competitive edge to organizations in the rapidly evolving business landscape. In essence, the integration of green innovation is pivotal for elevating environmental sustainability performance (Abbas and Khan, 2023; Hang *et al.*, 2022).

In addition to understanding the significant impact of green innovation on environmental sustainability performance, as discussed above, it is helpful to explore its determinants. Gaining insights into these factors can guide companies and inspire due attention to them, facilitating a comprehensive understanding of the causes and effects of green innovation. This broader perspective not only informs companies about the impacts of their actions, but also equips them to make more informed decisions in their journey towards sustainable growth. In light of this, previous studies have explored various elements influencing sustainable green product innovation, such as technology adoption, environmental regulations, and green supply chains. However, there remains a gap in understanding the contribution of factors like workforce agility, new product flexibility, and knowledge sharing with customers and suppliers to improve environmental performance and sustainable green product innovation.

We propose that organizations can drive a more sustainable future by using new product flexibility to enhance knowledge sharing with customers and suppliers, thus fostering green product innovation (Perera *et al.*, 2013). This study aims to highlight these critical but under-explored factors and their impact on sustainable practices. In the dynamic business environment of today, where companies must quickly adapt to shifting customer demands and strict environmental regulations, understanding the roles of workforce agility, new product flexibility, and collaborative knowledge sharing becomes crucial. These factors are key to strengthening green product innovation and environmental performance. New product flexibility, in particular, enables organizations to quickly adjust to market changes and mitigate environmental impacts by integrating innovative green solutions, demonstrating a strong commitment to environmental sustainability.

This study introduces a theoretical framework (see Figure 1) that advances our understanding of sustainable business practices, particularly in the context of developing countries like Jordan. It explores the dynamic interplay between workforce agility, knowledge sharing, and sustainable green product innovation, highlighting how these elements collectively enhance environmental sustainability and business strategy in a rapidly evolving global marketplace. This holistic approach addresses a notable gap in the

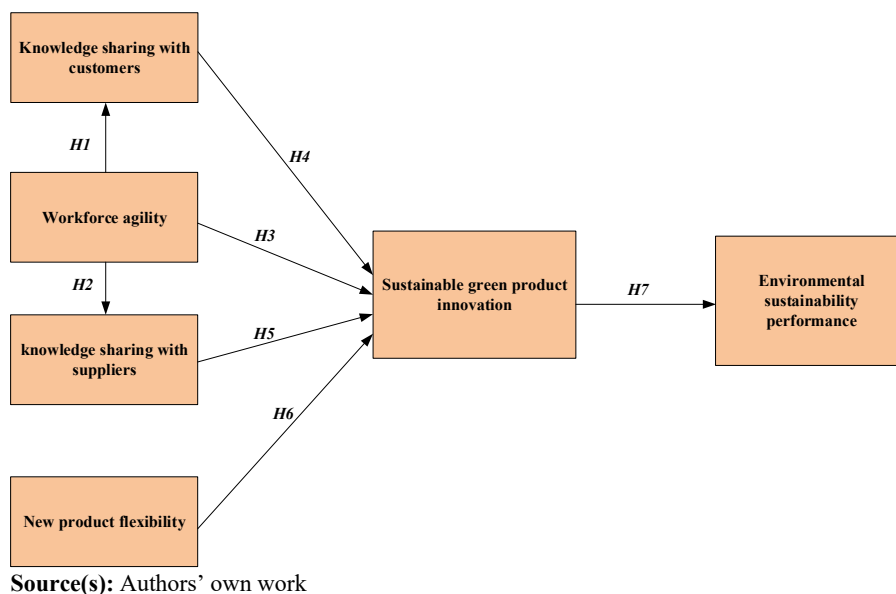


Figure 1. The proposed theoretical framework

literature, offering fresh insights into how these constructs interact in non-Western contexts and providing a nuanced understanding that enriches both academic and practical realms.

Our research goes beyond the traditional economic focus, examining how strategic and operational adaptations contribute to sustainable and environmentally conscious practices. By delineating the roles of green product innovation as both a dependent and independent variable, the study clarifies how internal organizational dynamics drive innovation and sustainability. The findings emphasize the need for organizations to foster a flexible, agile workforce and promote knowledge-sharing practices, which are crucial for enhancing green product innovation and achieving broader sustainability goals.

Moreover, our review of recent literature, including works by [He et al. \(2023\)](#) and [Xu et al. \(2022\)](#), reveals the positive impact of environmental leadership on green innovation. By introducing a novel model that considers green product innovation as both a catalyst and a result of environmental strategies, this study contributes to the ongoing discourse by demonstrating how internal capabilities are essential for driving innovation and attaining sustainability objectives. This aligns with the increasing calls from scholars like [Elbanna and Child \(2023\)](#) for meaningful research that significantly impacts policymakers and managers, providing a practical framework through which organizations can pursue sustainability while fostering economic growth.

The remainder of this paper is structured in six parts. Following this introduction, [Section 2](#) presents an extensive review of the relevant literature and hypothesis formulation. [Section 3](#) elaborates on the methodology, while [Section 4](#) analyzes the data collected. The findings and their implications are discussed in [Section 5](#), culminating in [Section 6](#) with the study's conclusions.

2. Literature review and hypothesis development

2.1 Workforce agility and knowledge sharing with customers and suppliers

Knowledge sharing with customers and suppliers is centered on the mutual exchange of information, insights, expertise, and experiences to foster close collaboration, enhance mutual

understanding, and stimulate the generation of new ideas through the sharing of critical information. Workforce agility is the ability of employees to adapt to change and respond effectively. By building employee skills and strengthening human capital, the workforce becomes more flexible and better equipped to cope with changes resulting from an uncertain business environment. It is crucial for facilitating the exchange of knowledge with both customers and suppliers (Hopp and Van Oyen, 2004; Shahzad *et al.*, 2020). Workforce agility enables employees to promptly respond to changes in the market and emerging trends, including the growing demand for environmentally friendly innovations. They can learn and share the latest information with customers and suppliers, ensuring that everyone is informed about the newest developments. Moreover, workforce agility serves as a customer-centric approach by comprehending and fulfilling customer needs. It involves the sharing of valuable insights and information with customers, enhancing their understanding of products or services and fostering a collaborative relationship. Additionally, workforce agility cultivates a culture of innovation and problem-solving. Agile employees are inclined to share creative solutions, best practices, and industry insights with both customers and suppliers, leading to an ongoing exchange of knowledge that benefits all stakeholders (e.g. Shahzad *et al.*, 2020).

Workforce agility, characterized by a flexible and adaptable workforce capable of swiftly adapting to new situations, technologies, and market demands (Dove, 2001), plays a pivotal role in facilitating knowledge sharing in business contexts. Knowledge sharing, broadly involves the exchange of information, ideas, and expertise crucial for the tasks performed by individuals, teams, work units, and the organization as a whole (Tohidinia and Mosakhani, 2010). When applied to interactions with customers and suppliers, this concept becomes integral to the involvement of these stakeholders in the New Product Development (NPD) process (Fang, 2008).

Christofi *et al.* (2024) highlight the critical synergy between knowledge management, information technology, and human resource management as foundational for strategic agility, which is essential for fostering workforce agility. This synergy facilitates knowledge sharing with customers and suppliers, crucial for driving sustainable green product innovation. In agile organizations, the integration of human capital, innovation, corporate social responsibility, and digitalization creates a supportive framework for adaptability and continuous learning, emphasizing the importance of sustainable innovation investments. Milani *et al.* (2024) further emphasize that today's complex business environment demands ongoing skill development and adaptability from leaders and employees. Workforce agility is key, enabling the acquisition of new skills necessary for sustainable innovation and the adoption of environmentally friendly practices.

Agile employees, particularly those with higher levels of education and training, are often more productive and receptive to new ideas and change (Kong *et al.*, 2020). This agility is instrumental in equipping employees with new skills and competencies, enabling them to respond effectively to changes driven by customer needs and market conditions (Breu *et al.*, 2001). Such a workforce is inherently more capable of engaging in meaningful knowledge sharing with external stakeholders, particularly in critical areas like new product development and environmental management solutions (Chen, 2022).

Chen (2022) emphasizes that knowledge sharing with suppliers integrates them into new product development, enhancing environmental management solutions. Kong *et al.* (2020) note that involving both suppliers and customers in product development and leveraging employee knowledge can significantly improve customer satisfaction and organizational performance. Furthermore, Joshi and Sharma (2004) argue that customer integration in product development helps customers understand limitations and adjust their expectations, facilitating smoother product introductions.

In addition, incorporating eco-friendly suppliers into the production process can enhance the green supply chain by reducing pollution emissions (Zhao *et al.*, 2018). The integration of supplier knowledge into the firm's knowledge base, including product innovation processes, transforms knowledge into a valuable resource (Chen, 2022). This integration leads to the

identification of distinctive competencies and opportunities for value creation. By sharing knowledge with customers and suppliers, firms can gain additional market insights and environmental perspectives, which can substantially improve the performance of new products (Fang, 2008).

Given these arguments, it becomes evident that workforce agility plays a crucial role in enhancing knowledge sharing with both customers and suppliers. This leads us to propose the following hypotheses:

- H1. Workforce agility positively influences knowledge sharing with customers
- H2. Workforce agility positively influences knowledge sharing with suppliers

2.2 Workforce agility and sustainable green product innovation

To embrace green innovation, a firm must fundamentally reorient its production activities and processes towards environmental sustainability (Chen, 2022). Green innovation is broadly characterized by technologies and production processes that contribute to energy conservation, pollution reduction, waste recycling, and the creation of environmentally friendly products (Chen *et al.*, 2006). This innovation transcends the traditional focus on a product's physical attributes and instead seeks to enhance overall value by providing holistic environmental solutions (Sherehiy and Karwowski, 2014).

In this context, workforce agility emerges as a critical facilitator of sustainable green product innovation. Agile workforces are adept at aligning business strategy with evolving environmental expectations, offering customers products that not only meet their needs but also create added ecological value (Hopp and Van Oyen, 2004). This requires firms to invest in hiring and training employees who are not only agile in their task execution but are also deeply ingrained with a culture of green innovation.

El-Sayed *et al.* (2025) demonstrate a strong positive link between organizational agility and green work behaviors among nurses, indicating that agility in healthcare settings significantly increases the adoption of environmentally sustainable practices. This relationship underscores the role of agility in creating an environment conducive to sustainable actions, highlighting its importance in rapidly implementing green initiatives and fostering innovative strategies (Sahoo and Chaubey, 2024). Further, research by Breu *et al.* (2001) supports the notion that workforce agility enhances employees' ability to develop new skills quickly, boosting their responsiveness to changing market demands. This agility not only empowers employees but also promotes interdepartmental collaboration, essential for driving green innovation. Overby *et al.* (2006) expand on this by noting that agile employees are particularly adept at sensing and responding to shifts towards green technologies, facilitating the seamless integration of environmentally friendly techniques into existing processes (Zhang and Sharifi, 2000; Chen *et al.*, 2006; Qin *et al.*, 2015).

In summary, agility within the workforce plays a pivotal role in enabling firms to not only adapt but also actively contribute to sustainable green product innovation. This leads us to propose the following hypothesis, which captures the strategic importance of workforce agility in aligning business objectives with environmental stewardship:

Formally:

- H3. Workforce agility positively affects sustainable green product innovation

2.3 Knowledge sharing with customers and sustainable green product innovation

Shared knowledge is a valuable resource that is vital for achieving a competitive advantage (Nonaka, 1994). According to Hong *et al.* (2004), the purpose of the shared knowledge of customers is to make a strategic fit between customer needs and a firm's capabilities. Therefore, team members involved in green product innovations leverage the integration of customer input into new green product development projects. This approach fosters a deeper

understanding of customer demands, ultimately boosting the performance of green product innovation (Hong *et al.*, 2004). Furthermore, by incorporating customers into their processes, organizations can reap substantial benefits such as heightened responsiveness, cost reduction, amplified value creation, and enhanced ability to swiftly identify changes in demand.

Chen and Chang (2012) argued that green innovation requires the generation of new ideas that result in making innovative green products, services, processes, and practices aimed at finding creative solutions to environmental challenges. In doing so, green dynamic capabilities and various practices are identified, such as acquiring and assimilating new knowledge pertaining to environmental sustainability, transforming resources to align with green objectives, and effectively managing human capital resources to facilitate the development of eco-friendly products. Therefore, this study hypothesizes that:

H4. Knowledge sharing with customers positively affects sustainable green product innovation

2.4 Knowledge sharing with suppliers and sustainable green product innovation

According to Hong *et al.* (2004), knowledge sharing with suppliers improves the production processes and this helps a firm makes cost-effective decisions, launches new products quickly, and adds value to customers by providing favorably perceived product quality. In essence, companies need to build relationships with suppliers to facilitate knowledge sharing and strategize for the introduction of new green products. This collaborative approach aids them in shaping their operations plans to adopt green practices and thereby fostering a culture of green innovations. More precisely, involving suppliers in the processes of new product development contributes significantly to both innovation capability and operational performance. This engagement results in greater development flexibility, elevated product quality, a shorter time to market, and a reduction in development time and costs, as highlighted by Johnsen (2009). It also aligns with the notion that companies stand to gain advantage by integrating suppliers into their product innovation initiatives, with a specific focus on enhancing innovation capabilities, as indicated by Petersen *et al.* (2005). Furthermore, Primo and Amundson (2002) provided evidence of a positive association between supplier quality control and the extent of supplier involvement, along with a significant positive correlation between supplier involvement and product quality.

Nevertheless, innovative companies are well-positioned to adopt green practices and adapt to changing market demands, especially when using an agile organizational structure that facilitates rapid responses to customer needs (Yusr *et al.*, 2020). Lin and Chen (2017) contend that organizations can gain a competitive edge in the marketplace by sharing knowledge related to environmental sustainability, leading to enhanced green competitiveness and sustainable development. Hence, this study hypothesizes:

H5. Knowledge sharing with suppliers positively affects sustainable green product innovation

2.5 New product flexibility and sustainable green product innovation

Zhang *et al.* (2003) conceptualized product development flexibility as comprising three distinct dimensions: product concept flexibility, prototype flexibility, and product modification flexibility. Product concept flexibility involves the ability to rapidly generate ideas and maintain a range of potential product concepts and definitions. Prototype flexibility refers to a firm's capacity to quickly and cost-effectively build and modify product samples. Finally, product modification flexibility enables a company to promptly and effectively accommodate customer requests for design changes.

Aligning these dimensions of product flexibility with the sustainable development goals articulated in the Brundtland Report (Brundtland, 1987), which defines sustainable development as the ability to meet present needs without compromising the ability of future

generations to meet theirs, we see a clear intersection. This intersection is particularly relevant in the context of green product innovation, where flexibility in product design and development plays a crucial role in addressing the dual needs of current and future environmental sustainability.

Shukla *et al.* (2010), alongside Fatima and Elbanna (2023), Shrivastava (1995), and Gladwin *et al.* (1995), emphasize the importance of integrating sustainability into operational and strategic practices. This involves managing environmental risks and focusing beyond short-term economic gains. New product flexibility is crucial for adapting quickly to environmental and customer demands. Brown *et al.* (2005) highlight that this flexibility enhances sustainability performance in dynamic business environments, enabling organizations to meet specific customer needs with timely, eco-friendly, and diverse product offerings. Krajewski *et al.* (2005) and Asadi *et al.* (2019) agree, noting that combining such flexibility with production agility allows for effective change management and supports a customization strategy that prioritizes environmental sustainability. Based on this understanding, our study proposes the following hypothesis:

H6. New product flexibility positively affects sustainable green product innovation.

2.6 Sustainable green product innovation and environmental sustainability performance

In the era of Industry 4.0, organizations face pressures to adopt practices that enhance both economic and environmental performance. According to Wang *et al.* (2022), the aim of green innovation is to create an ecosystem that reduces energy use, increases resource efficiency, manages emissions, and promotes waste recycling. This not only improves environmental performance but also supports a healthier ecosystem. Fatima and Elbanna (2023) argue that in addressing global environmental challenges, organizations must integrate green innovations into their various operations and activities. Recent studies emphasize the importance of identifying drivers of environmental performance through green innovation. Tu (2024) provides empirical evidence that innovations in climate change technologies significantly boost environmental performance, suggesting a need for governmental support to enhance such innovations for better sustainability outcomes. Opazo-Basáez *et al.* (2023) and Rahmani *et al.* (2024) reinforce this by showing how green product and process innovations are crucial for achieving sustainability goals, conserving natural resources, and promoting economic growth, offering essential insights for scholars, policymakers, and stakeholders.

Sustainable green product innovation aims to reduce the environmental impacts caused by industrial activities, which involve transforming inputs into outputs. Shukla *et al.* (2009) discuss how green supply chain management (GSCM) ensures sustainability by mitigating or eliminating detrimental impacts across all business operations and outcomes. Hervani *et al.* (2005) further elaborate that GSCM involves greening every stage of the supply chain, from procuring raw materials to delivering finished products to consumers.

Stakeholders, including businesses, policymakers, and researchers, exert pressure on companies to mitigate adverse effects from manufacturing processes, particularly emissions like carbon dioxide, carbon monoxide, and fly ash (Junaid *et al.*, 2022). This collective emphasis on sustainable innovation in green products is highlighted by Obeidat *et al.* (2020), who note the importance of integrating eco-friendly practices and technologies throughout the product development process. This approach not only meets consumer needs but also aligns with ecological considerations. By merging green supply chain practices with sustainable product innovation, companies aim to create products that are not only innovative but also environmentally conscious. This strategy responds to the evolving expectations of stakeholders and consumers, whose environmental awareness is strengthening.

Consequently, to sustain green product innovation performance that ultimately leads and contributes to environmental sustainability performance, organizations have to adopt the best practices of operations (Bhatti *et al.*, 2023; Shahzad *et al.*, 2020). Implementing Green

Innovation (GI) and CSR best practices enhances environmental performance while aligning with stakeholder expectations, thereby fostering positive economic, social, and environmental impacts. Moreover, CSR initiatives have been shown to directly and positively influence the adoption of green practices and drive green innovation, further strengthening environmental performance (Yousaf *et al.*, 2024). These insights are consistent with the findings of Khan *et al.* (2024), who argue that companies dedicated to environmental responsibility and sustainability are more likely to engage in green innovation, thereby enhancing environmental performance. Their study demonstrates that both CSR and a strong commitment to green practices positively influence environmental and financial outcomes.

In this context, Chang (2011) argues that green innovation is becoming a main strategic tool for increasing sustainable performance in response to the call for increasing organizational awareness of environmental issues. Environmental performance, however, is a positive outcome that a firm is trying to achieve and improve in order to satisfy its stakeholders “claims and needs” (Obeidat *et al.*, 2020). In other words, environmental performance is becoming a necessity for the success and long-term survival of any business (Moussa *et al.*, 2020; Perera *et al.*, 2013). In this vein, Chen (2008) asserts that an organization’s dedication to environmental protection not only shields it from potential penalties but also enhances its corporate image, ultimately resulting in sustained competitive advantages. Examining the literature on sustainability (e.g. Shen *et al.*, 2007; Saeed and Kersten, 2020; Rupa and Saif, 2021) reveals that environmental sustainability performance is evaluated on the basis of criteria such as maximizing resource use, incorporating renewable resources, enhancing product quality, and using recyclable resources.

Baquero (2024) highlights that green innovation not only strengthens environmental performance but also attracts eco-conscious consumers, thereby enhancing market share, reputation, and profitability. He further notes that ambidextrous green innovation positively impacts the economic, social, and environmental aspects of sustainable performance. Supporting this, Wang and Ozturk (2023) provide empirical evidence that green supply chain management significantly boosts environmental performance, particularly through initiatives like customer collaboration, environmental management strategies, and green procurement. They argue that engaging stakeholders such as customers enhances environmental outcomes through eco-friendly designs, sustainable production, green packaging, and energy-efficient transportation methods. Additionally, Zhao *et al.* (2024) establish that green innovation is crucial for improving carbon reduction performance and mediates the relationship between business strategy and environmental outcomes.

Kobarg *et al.* (2020) suggest that ecological innovations in processes, products, or systems not only confer competitive advantages but also promote environmental sustainability by minimizing the negative impacts of production on the environment. Based on these insights, we propose the following hypothesis:

- H7. Sustainable green product innovation positively affects environmental sustainability performance.

3. Research methods

3.1 Questionnaire and measures

To examine the proposed hypotheses, this study relied on established and previously tested and validated measurement scales. The three-part study questionnaire is multidimensional and incorporates six variables (see Appendix). Part one deals with the respondent’s sociodemographic data. In part two comprising technical questions, participants were required to express their agreement level using a 7-point Likert scale, where (1) represented strongly disagree and (7) represented strongly agree. Part three collected basic information about the manufacturing industry.

Environmental sustainability performance is adopted from [Chow and Chen \(2012\)](#), and knowledge sharing with customers and suppliers' scales was adapted from [Singh and Power \(2013\)](#). Whereas the workforce agility scale is adopted from [Muduli \(2017\)](#), the new product flexibility scale is adopted from [Fantazy and Salem \(2016\)](#), and [Awwad et al. \(2022\)](#), while the sustainable green product innovation scales are adopted from [Chen et al. \(2006\)](#). The original survey items were next translated into Arabic. Furthermore, due to the challenges associated with probabilistic sampling in Arabic countries ([Elbanna et al., 2020](#)), a non-probabilistic sampling method was employed to collect data from potential respondents. To ensure the content validity of the survey, it was pre-tested with four experts in strategic management. Moreover, to establish face validity in terms of the readability and clarity of the survey items, a pilot study was conducted with 32 prospective participants. These procedures resulted in several adjustments to the survey to better suit the study's setting.

3.2 Sampling design

The sampling design was carefully considered to align with the research objectives ensuring that the collected data is representative of the managerial context in Jordan's industrial sectors. Managers were targeted to respond to this study because their strategic perceptions in this regard are crucial to understanding such organizational behaviors and outcomes. Online survey methods were preferred for efficiency in this regard and the possibilities it has to reach a wide range of respondents from various industrial sectors. Since industrial firms in Jordan are geographically dispersed, an online survey method was considered feasible and timely in order to ensure comprehensive coverage.

The data were collected using a non-probabilistic sampling method due to the challenges of data collection in Arab countries, as noted by several researchers (e.g. [Elbanna and Child, 2007](#)). Although such a technique is usually associated with a number of biases, including selection bias, for the purpose of this study, it would be deemed appropriate, given that the data needed to be drawn from a category of respondents possessing relevant knowledge, more so at a managerial level across board. For this reason, bootstrapping techniques available in Structure Equations Modeling (SEM) were used to resolve these issues and reinforce the findings of the study. The result is that bias is minimal while at the same time increasing the reliability of the estimates of the parameters and, as such, contributes to better validity of research outcomes. An online survey was distributed between June and November 2022. This study targeted managers of the Jordanian industrial sector. The breakdown of the targeted companies' activities is presented in [Table 1](#).

The above industries were targeted and represent the primary sampling unit, whereas the secondary unit was a management group of supervisor and direct managers, middle and above. Out of 600 distributed questionnaires, only 448 were completed and included in the next step (analysis) revealing a response rate of 74.67%. A sample of 448 is sufficient to conduct this study. [Table 2](#) illustrates the characteristics of the respondents.

Table 1. Breakdown of the industry

Sector	Number of respondents	Percentage
Chemical and Pharmaceutical Products	90	20.1%
Food and Beverages	75	16.7%
Textiles, Leather and Clothing	74	16.5%
Electronics, Engineering and Construction	72	16.1%
Extraction, Mining, Ceramics and Glass	48	10.7%
Others: Paper and Cardboard	89	19.9%
Total	448	100

Source(s): Authors' own work

Table 2. Characteristics of respondents

Indicators	Category	Number	Percentages
Gender	Male	245	54.69%
	Female	203	45.31%
Age	25 years or less	145	32.37%
	26–35 years	98	21.88%
	36–45 years	120	26.79%
	46 years and above	85	18.97%
Experience in the current position	Less than one year	115	25.67%
	1–5 years	196	43.75%
	Above five years	137	30.58%
Functional area	Marketing and sales	257	57.37%
	Operations	83	18.53%
	Accounting or finance	48	10.71%
	Others	60	13.39%
Managerial level	Lower/middle level	323	72.10%
	Top level	125	27.90%

Source(s): Authors' own work

Table 2 shows that 54.69% of the respondents were male. In terms of age, most respondents (67.64%) are older than 26 years, and in terms of experience, approximately 75% had more than five years of experience in their current positions. Moreover, a majority of the respondents (57.37%) are working in the sales and marketing department. Furthermore, approximately 72% of the respondents held supervisory positions, while around 28% held senior management positions.

To test the proposed framework, structural equation modeling was used. First, to fully analyze the appropriateness and sufficiency of the measurement model, a series of analyses, including reliability assessment, validity assessment, and confirmatory factor analysis, was conducted. Subsequently, the structural model was examined to determine the significance of the proposed hypotheses.

4. Data analysis

Several actions were taken to enhance the questionnaire's reliability and validity and to minimize the impact of response bias throughout the research process. These measures included modifying some questionnaire items and eliminating outliers using the Mahalanobis distance technique in the Analysis of Moment Structures (AMOS).

4.1 Reliability and validity

As the study scales were developed for various cultures and purposes, certain aspects may not be applicable to Jordanian culture. Consequently, modifications were made to align the scales with the specific focus of this study. A reliability test was conducted by the consistency coefficient (Cronbach's alpha), the results of which are presented in **Table 3**. Any value above 0.70 was considered to be good.

Before proceeding with the factor analysis, Bartlett's Test of Sphericity and KMO test were carried out to determine sampling the adequacy and strong correlations among variables. A KMO value higher than 0.60 is considered to indicate good sampling adequacy. Bartlett's test of Sphericity indicates strong correlation among at least one pair of variables. A KMO value of 0.92 and a significant *p*-value of 0.00 indicated that the preliminary tests were successful and the factor analysis could proceed. Exploratory Factor Analysis (EFA) was performed using the Maximum Likelihood Extraction (MLE) method to identify the latent dimensions, as

Table 3. Factor loadings and reliability of the measures

Constructs (sample = 448)	Number of items	Factor loading
<i>Knowledge sharing with customers</i>	6	
Cronbach's alpha = 0.911, Composite reliability (rho_c) = 0.909, AVE = 0.663		
- Knowledge sharing with customers 1		0.749
- Knowledge sharing with customers 2		0.741
- Knowledge sharing with customers 3		0.841
- Knowledge sharing with customers 4		0.871
- Knowledge sharing with customers 5		0.778
- Knowledge sharing with customers 6		0.784
<i>Knowledge sharing with suppliers</i>	4	
Cronbach's alpha = 0.869, Composite reliability (rho_c) = 0.855, AVE = 0.636		
- Knowledge sharing with suppliers 1		0.901
- Knowledge sharing with suppliers 2		0.913
- Knowledge sharing with suppliers 3		0.765
- Knowledge sharing with suppliers 4		0.556
<i>Workforce agility</i>	5	
Cronbach's alpha = 0.907, Composite reliability (rho_c) = 0.913, AVE = 0.665		
- Workforce agility 1		0.61
- Workforce agility 2		0.73
- Workforce agility 3		0.89
- Workforce agility 4		0.90
- Workforce agility 5		0.90
<i>New product flexibility</i>	3	
Cronbach's alpha = 0.924, Composite reliability (rho_c) = 0.868, AVE = 0.748		
- New product flexibility 1		0.901
- New product flexibility 2		0.925
- New product flexibility 3		0.897
<i>Sustainable green product innovation</i>	4	
Cronbach's alpha = 0.897, Composite reliability (rho_c) = 0.895, AVE = 0.692		
- Sustainable green product innovation 1		0.746
- Sustainable green product innovation 2		0.903
- Sustainable green product innovation 3		0.903
- Sustainable green product innovation 4		0.777
<i>Environmental sustainability performance</i>	4	
Cronbach's alpha = 0.917, Composite reliability (rho_c) = 0.918, AVE = 0.736		
- Environmental sustainability performance 1		0.847
- Environmental sustainability performance 2		0.847
- Environmental sustainability performance 3		0.925
- Environmental sustainability performance 4		0.812

Source(s): Authors' own work

recommended by [Hair et al. \(2010\)](#). [Table 3](#) revealed six factors derived from the 26 variables, explaining a significant portion (76.52%) of the total variance. The summarized factor loadings, as presented in [Table 3](#), are well above the 0.50 threshold, demonstrating a close association between the items and their respective factors.

4.2 Confirmatory factor analysis (CFA)

In order to enhance the psychometric properties of the scale, the identified factors in the exploratory factor analysis are used to conduct a CFA.

Table 4 shows that the average variance extracted (AVE) values for all structures exceeded 0.50, and the CR values ranged between 0.85 and 0.92, indicating strong internal consistency (Nunnally and Bernstein, 1994). All construct loadings demonstrating statistical significance at $p = 0.001$. These results indicate that all constructs satisfied the criteria for discriminant and convergent validity. Consequently, the validity and reliability of the measurement model were effectively confirmed. The CFA result further demonstrated a good fit between the model and the data ($X^2 = 1139.837$, $df = 241$, $(X^2/df = 4.73)$, $p < 0.001$, $GFI = 0.937$, $NFI = 0.91$, $SRMR = 0.07$ and $RMSEA = 0.09$). Additionally, all items exhibited factor loadings above 0.60 on their respective constructs, and are significantly associated with their designated constructs ($p < 0.01$). These findings provide supporting evidence for the unidimensionality of each scale. As a result, the structural model (final model), was chosen to be used for further discussion.

4.3 Measurement model result

The final model was subjected to a comprehensive evaluation in comparison to the original framework, wherein multiple goodness-of-fit indicators were examined. The results indicate that the final model demonstrated enhanced fit characteristics when compared to the initial proposed model ($X^2 = 604.841$, $df = 233$, $(X^2/df = 2.596)$, $p < 0.001$, $GFI = 0.896$, $NFI = 0.936$, $SRMR = 0.08$ and $RMSEA = 0.06$). As a result, the structural model was found able to achieve an excellent fit with the collected data. Next in the model estimation process the relevance of each hypothesized path was examined. Two stages were used to test the proposed hypothesis: direct effects (H1–H7) (see Table 5).

4.4 Testing the direct relationships

The purpose of this action was to study the direct effects of workforce agility on knowledge sharing with customers, knowledge sharing with suppliers and sustainable green product innovation. Table 5 shows a significant positive impact of workforce agility on knowledge sharing with customers ($\beta = 0.571$, $p < 0.001$). Likewise, there is a significant positive effect between workforce agility and knowledge sharing with suppliers ($\beta = 0.496$, $p < 0.001$) supports both H1 and H2. Similarly, there is a significant positive effect of workforce agility on sustainable green product innovation ($\beta = 0.117$, $p < 0.031$) that support H3.

Furthermore, Table 5 shows a significant positive impact of knowledge sharing with customers on sustainable green product innovation ($\beta = 0.388$, $p < 0.001$), which supports H4. The impact of knowledge sharing with suppliers on sustainable green product innovation ($\beta = 0.112$, $p < 0.049$) support H5. The results also demonstrate a significant positive relationship between new product flexibility and sustainable green product innovation ($\beta = 0.091$, $p < 0.055$), supporting H6 and a significant positive relationship between sustainable green product innovation and environmental sustainability performance ($\beta = 0.553$, $p < 0.001$), confirming H7.

Table 4. Reliability and convergent validity^a

	CR	AVE	1	2	3	4	5	6
1. Environmental sustainability performance	0.92	0.74	0.86					
2. Knowledge sharing with customers	0.91	0.63	0.44	0.80				
3. Workforce agility	0.88	0.65	0.33	0.58	0.82			
4. Knowledge sharing with suppliers	0.89	0.64	0.37	0.62	0.47	0.80		
5. New product flexibility	0.85	0.75	0.45	0.64	0.53	0.57	0.87	
6. Sustainable green product innovation	0.90	0.69	0.59	0.55	0.37	0.43	0.51	0.84

Note(s): ^aThese metrics are computed using the Excel StatTools developed by Gaskin (2016). The specific source for this package can be found at the following web address: <http://statwiki.kolobkreations.com>

Source(s): Authors' own work

Table 5. Structural parameter estimates (standardized coefficients)

Hypothesis	Standardized estimate	p-value	Results
H1: Workforce agility → knowledge sharing with customers	0.571	15.088***	Supported
H2: workforce agility → knowledge sharing with suppliers	0.496	10.673***	Supported
H3: workforce agility → sustainability green product innovation	0.117	1.873**	Supported
H4: knowledge sharing with customers → sustainability green product innovation	0.388	5.869***	Supported
H5: knowledge sharing with suppliers → sustainability green product innovation	0.112	1.657**	Supported
H6: New product flexibility → sustainability green product innovation	0.091	1.595*	Supported
H7: Sustainability green product innovation → environmental sustainability performance	0.595	12.384***	Supported

Note(s): **Significant at $\alpha \leq 0.05$
*Significant at $\alpha \leq 0.01$
***Significant at $\alpha \leq 0.001$
Source(s): Authors' own work

The structural model used in this study explains 29.9% ($R^2 = 0.299$) of the variance in the adoption of sustainable green product innovation. Additionally, the model explains 30.6% ($R^2 = 0.306$) of the variance in the adoption of environmental sustainability performance, which is above the cut-off value of 10% (Falk and Miller, 1992).

5. Discussion

This study explores a pivotal subject: innovation for a more sustainable future. It seeks to enhance our comprehension by elucidating the significance of workforce agility, the capacity for novel product adaptation, collaborative knowledge exchange with both customers and suppliers in the context of sustainable green product innovation, and the resultant influence on environmental sustainability performance.

The first two hypotheses posit that a workforce characterized by agility—marked by flexibility and adaptability—positively influences the sharing of knowledge with both customers and suppliers. This assertion is supported by our data and a growing corpus of research in organizational behavior and human resource management, as evidenced by the works of Clarke *et al.* (2023), El-Kassar and Singh (2019), Eslami *et al.* (2023), Gusenbauer *et al.* (2023), and Awwad *et al.* (2022). In the contemporary business landscape, knowledge is increasingly recognized as a pivotal asset for competitive advantage and organizational renewal, a perspective echoed by Degbey and Pelto (2021). Effective knowledge sharing, encompassing the exchange of information about core problems and collaborative solution-finding, is instrumental in sustaining business success.

In addition, Singh and El-Kassar (2019) highlight the commitment of businesses to foster innovation by adopting cutting-edge technologies and implementing comprehensive training programs. These initiatives aim to enhance the knowledge base and performance sustainability of employees. However, as Ilvonen *et al.* (2018) caution, the dissemination of knowledge is not without risks. They advocate for the implementation of robust protocols to ensure the secure and strategic transfer of information, thereby mitigating potential misuse or unintended dispersion of knowledge. Consequently, to cultivate an environment conducive to innovation, organizations need to proficiently navigate and reassemble existing knowledge fragments. This process, as Gusenbauer *et al.* (2023) emphasize, involves generating novel and unique combinations of knowledge elements, which is fundamental in driving the innovation agenda forward.

Building on the previous discussion about the impact of workforce agility on knowledge sharing with customers and suppliers, we extend our analysis to examine the broader implications of this agility in optimizing competencies and fostering sustainable green product innovation. It is posited within the scope of our research that agile workforces are not only adept at sharing knowledge but also excel in proactively enhancing their skill sets to meet evolving demands, as suggested by [Breu et al. \(2001\)](#). This capacity for self-improvement and adaptation is crucial in today's rapidly changing business environment. [Suofi et al. \(2014\)](#) further reinforce this notion, identifying a positive correlation between the fluid sharing of information and the agility of workers. This finding aligns with the core focus of our paper on the synergy between internal capabilities and external collaboration for innovation. Moreover, our study reveals a significant positive relationship between workforce agility and sustainable green product innovation, echoing the findings of [Wong et al. \(2020\)](#). These studies suggest that companies exhibiting higher levels of agility are more inclined towards innovation, especially when it involves collaborating externally. Such firms are often more responsive to environmental concerns and adept at integrating sustainable practices into their product development process. This observation is pivotal in understanding how an agile workforce can be a catalyst for sustainable green product innovation, directly contributing to the overall strategic goals of environmental sustainability and competitive advantage in the business sector.

In summary, our study validates the critical role of workforce agility in enhancing internal knowledge dynamics and driving external sustainable innovation initiatives. This finding underscores the value of agility in the interplay between human resource practices and green product innovation in contemporary businesses. Organizations that develop agile workforces are better positioned to collaborate effectively with stakeholders, leverage expertise for continuous improvement, and embrace sustainable innovation. This agility enables them to respond adeptly to sustainability challenges, fostering collaborative and innovative approaches in sustainable product development.

[H4](#) and [H5](#) received support, indicating that active involvement in knowledge sharing with suppliers and customers exerts a positive influence on sustainable green product innovation. This proposition is supported by recent research in the fields of organizational behavior and sustainable innovation. For instance, [Geffen and Rothenberg \(2000\)](#) have observed the critical role of suppliers in contributing novel technologies and materials to the sustainable green product innovation. Concurrently, customers provide essential insights into market dynamics and product demand, as highlighted by [Dai et al. \(2015\)](#). This synergy, where suppliers offer green technology expertise and customers share market-oriented environmental sustainability insights, greatly facilitates sustainable green product innovation. Further emphasizing the economic benefits of this collaboration, [Zhu et al. \(2012\)](#) demonstrated significant advantages for companies that integrate suppliers and customers into the sustainable green product innovation process. This notion of collaborative effort extending beyond organizational boundaries, as espoused by [Prajogo et al. \(2014\)](#), is especially important in areas where in-house knowledge of emerging technologies is limited.

Consistent with related research (e.g. [Brown et al., 2005](#)), [H6](#) provides empirical evidence supporting the notion that an organization's capacity to promptly adapt and respond to shifting market demands and changing environmental conditions through the implementation of new product flexibility not only contributes to sustainable green product innovation but also facilitates the alignment of a company's sustainability initiatives with its overarching business strategy and the evolving requirements of its customer base. This acceptance of the hypothesis underscores the pivotal role that new product flexibility plays in harmonizing sustainability efforts with business objectives and customer preferences. [H7](#) was similarly affirmed, highlighting a close and significant connection between green product innovation and environmental performance. Similarly, [Christmann \(2000\)](#) argued that green product innovation leads to increased profits by allowing companies to charge a premium for environmentally friendly products. Likewise, [De Giovanni and Vinzi \(2012\)](#) have supported

this argument. Furthermore, green innovation has been found to facilitate energy and fuel savings, reduce the consumption of raw materials, and minimize waste and emissions (Alamro *et al.*, 2018; Shrivastava, 1995).

These findings highlight how the theoretical frameworks of Resource-Based View (RBV), Knowledge Management (KM), and Sustainable Development provide profound insights into the unique capabilities developed by Jordanian industrial firms to maintain competitive advantage in resource-constrained environments. These firms leverage their knowledge assets and capabilities to drive sustainability innovations, particularly crucial in contexts of limited natural resources, financial capital, and advanced technologies. Drawing from RBV, they prioritize intangible assets like organizational knowledge, human capital, and learning systems as primary drivers of innovation. Barney (1991) suggests that such focus allows firms to overcome resource limitations by exploiting internal capabilities for incremental growth.

In Jordanian companies, KM practices are carefully tailored to align with the local culture and market dynamics, reflecting the collectivist nature of Jordanian society which places a high value on interpersonal relations, trust, and collaboration (Ayoub *et al.*, 2017). These predominant Arab cultural traits significantly influence the mechanisms through which knowledge is shared and utilized within organizations, leading to the development of KM systems that emphasize relational trust and collaborative networks (Elbanna *et al.*, 2020). Such culturally aligned practices not only enable firms to foster innovation and agility, which are essential for navigating the dynamic market environment, but also serve as practical applications of KM theory.

Building upon the foundations of Sustainable Development theory, Jordanian firms actively balance economic growth with pressing environmental and social concerns, especially given Jordan's limited natural resources such as water and energy. The adoption of the Triple Bottom Line approach by many firms involves integrating resource-efficient processes with renewable energy initiatives, aiming to harmonize economic, environmental, and social outcomes (Silvestre and Fonseca, 2020). This strategic integration not only enriches our theoretical understanding of sustainable development within the context of a developing country's industrial sector but also highlights the practical implications of this theory in managing real-world challenges. By contextualizing these theoretical frameworks within Jordanian industrial practices, the study sheds light on how theoretical constructs interact and are applied in management practices.

By directly connecting these theoretical frameworks back to the observed KM and sustainable practices within Jordanian companies, this discussion underscores how both management theory and practice are advanced, providing a clearer understanding of the applicability and impact of these theories in a real-world setting. This approach not only addresses gaps in the literature but also illustrates the practical relevance of academic theories in improving managerial effectiveness and strategic decision-making.

6. Conclusion

This study significantly advances our understanding of the roles of workforce agility and knowledge sharing in fostering sustainable green product innovation, resonating with the frameworks of resource-based view, knowledge management, and sustainable development theories. Our findings highlight the critical importance of internal capabilities—particularly an agile workforce and effective knowledge sharing processes—as strategic resources that drive competitive advantage in green innovation, affirming the resource-based view articulated by Wernerfelt (1984). Additionally, the research enhances knowledge management theory by demonstrating how sharing knowledge internally and externally spurs sustainable green innovation and ecological sustainability, aligning with Drucker's (1993) focus on continuous learning and information dissemination to improve organizational policies. It also supports sustainable development theory by illustrating the role of green product innovation in

promoting environmental sustainability, extending [Brundtland's \(1987\)](#) principles to show how businesses can integrate green practices into their strategies to conserve resources and boost sustainability.

In sum, this study links empirical evidence with core theories, offering a comprehensive view of how strategic resource management and collaborative knowledge sharing contribute to sustainable development. The findings emphasize the importance of internal agility and external collaboration in driving innovations that enhance environmental sustainability.

On a practical note, this study provides actionable insights for managers and decision-makers focused on enhancing their firm's sustainability. It emphasizes the strategic value of workforce agility in fostering an environment conducive to knowledge sharing with stakeholders, crucial for driving sustainable green product innovation. To support this, firms are encouraged to invest in training programs that improve employee agility and adaptability, aligning workforce capabilities with long-term sustainability objectives. Additionally, the research highlights the importance of collaborative innovation, urging organizations to facilitate interactions with customers and suppliers. By creating platforms for dialog and integrating stakeholder feedback into development processes, firms can enhance their innovative capacity and adapt more rapidly to market and customer sustainability demands. Furthermore, the adoption of flexible product development strategies is advocated to ensure that operational tactics are responsive to environmental sustainability goals, thereby strengthening the firm's competitive position in the market.

While this study offers valuable insights, its geographical focus on Jordan limits the generalizability of the findings. To enhance the applicability across different regions, future research should consider a broader sampling strategy that includes diverse workforce populations and industries from multiple geographic areas. This expansion would not only improve the representativeness of the results but also allow for comparisons and contrasts across different cultural and economic contexts. Moreover, the measurement methods for workforce agility, knowledge sharing, and sustainable green product innovation might not fully capture these complex concepts, recommending a refined approach, possibly incorporating qualitative methods for deeper insights. While this study identifies significant relationships between variables, it employs a cross-sectional design, which inherently limits our ability to assert causality. Recognizing this limitation, we suggest future research could adopt longitudinal or experimental designs to more definitively explore cause-and-effect dynamics. Additionally, external factors such as market dynamics, regulatory changes, and technological advancements play a crucial role in sustainable innovation but were not fully accounted for in this study. We recommend that subsequent studies incorporate these elements to provide a more comprehensive understanding of the factors influencing sustainable innovation. Other potential influences such as organizational culture, leadership style, and resource allocation also warrant exploration to understand their interplay with workforce agility and knowledge sharing in driving sustainable innovation. Addressing these areas will enrich the current study's contributions and offer a more thorough understanding of the dynamics influencing sustainable green product innovation and environmental sustainability.

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Table A1. Questionnaire items

Constructs (sample = 448)	Number of items	Cronbach's alpha	Factor loading
<i>Knowledge sharing with customers</i>	6	0.909	
- The organization is aware of the requirements of its customers			0.749
- Customers are encouraged to provide feedback			0.741
- Customer feedback is used to improve customer relations, processes, products and services			0.841
- The organization has systematic processes for handling complaints			0.871
- Misunderstandings between customers and organization about orders are rare			0.778
- Customers contribute to the development of the organization's values			0.784
<i>Knowledge sharing with suppliers</i>	4	0.869	
- The organization seeks long-term stable relationships with suppliers			0.901
- The organization seeks assurance of quality from suppliers			0.913
- Suppliers are provided with information so that they can improve their quality and responsiveness			0.765
- Suppliers are involved in the development of new products			0.556
<i>Workforce agility</i>	5	0.907	
- I am comfortable with change, new ideas, and new technologies in my organization			0.61
- I am flexible to quickly change from task to task, job to job, and place to place			0.73
- I map my skills, benchmark for skill assessment, and develop skills			0.89
- I am comfortable with cross-functional project teams, collaborative ventures with other companies, or with a virtual organization			0.90
- I am tech-savvy and have knowledge in advanced manufacturing technologies, IT skills, use of mobile technologies, etc			0.90
<i>New product flexibility</i>	3	0.924	
- Our company is able to introduce and manufacture new parts and products at a low cost			0.901
- Our company is able to launch new part and products quickly in a short time			0.925
- Our company is able to manage the time and cost to perform design activities concurrently			0.897
<i>Sustainable green product innovation</i>	4	0.897	
- Our company chooses the materials of the product that produce the least amount of pollution for conducting the product development or design			0.746
- Our company chooses the materials of the product that consume the least amount of energy and resources for conducting the product development or design			0.903

(continued)

Table A1. Continued

Constructs (sample = 448)	Number of items	Cronbach's alpha	Factor loading
- Our company uses the fewest amount of materials to comprise the product for conducting the product development or design			0.903
- Our company would circumspectly deliberate whether the product is easy to recycle, reuse, and decompose for conducting the product development or design			0.777
<i>Environmental sustainability performance</i>	4	0.917	
- Our firm reduced energy consumption			0.847
- Our firm reduced wastes and emissions from operations			0.847
- Our firm reduced purchases of non-renewable materials, chemicals, and components			0.925
- Our firm reduced the environmental impacts of its products/service			0.812
Source(s): Authors' own work			

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