A Mediation Framework: Green Innovation as a Mediating Bridge Between Knowledge Management Processes and Business Sustainability

Khalid Abbas
Liverpool Business School, University of Liverpool, UK.

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Abstract

Organizations are systematically including sustainability considerations in their strategic frameworks, given the rise of environmental challenges and increasing stakeholder demands. This paper proposes and empirically validates a mediation framework in which green innovation is a significant mechanism linking knowledge management processes & business sustainability. Drawing via dynamic capability theory & RBV, we argue that appropriate knowledge-management processes enhance the development of green innovations, which in turn enhance the environmental, economic, and social sustainability dimensions. Using SEM to assess survey data from 327 companies in various industries in Pakistan, we find strong evidence that emphasizes the green innovation mediating role. Results indicate that knowledge management processes affect green innovation ($\beta = 0.62$), which, in turn, exerts a significant effect through business sustainability ($\beta = 0.48$). Furthermore, the indirect effect remains statistically significant at 95% CI [0.21, 0.39], which supports the partial mediation. The present study enriches theoretical understanding by integrating existing literature on knowledge management, green innovation, and sustainability, and provides practical implications for managers interested in leveraging knowledge for achieving sustainable advantage.

Keywords: Knowledge management; Green innovation; Business sustainability; Mediation; RBV; Dynamic capabilities

1. Introduction

During past decades, environmental degradation, climatic upheavals, and resource depletion have made sustainability a strategic imperative for corporations across the world, rather than an ethical obligation. Firms operating within diverse industries are increasingly expected to work out their activities sustainably by stakeholders, regulators, and society at large (Kraus et al., 2020). Growing awareness that corporate operations contribute to the environmental crises of carbon emission and biodiversity degradation has increased the demand for sustainability in corporate strategy (Dahlmann et al., 2019). Recently, KM and GI have been a research focus in realizing business sustainability (BS) in information-based economies (Aljehani et al., 2024). Firms have to bear rapid technological shifts, intense competitive pressures, and uncertainties regarding the environment. Knowledge as a strategic resource is increasingly regarded as a source of innovation and adaptability for an organization (Dahlquist, 2021; Wan and Du, 2022). Sustained firm advantages originate from its capabilities related to knowledge creation, storage, sharing, and application. How KMPs can contribute towards environmental sustainability is not well examined (Al Koliby et al., 2022a). Hence, GI is obtained via the creation of environmentally friendly goods and management practices (Hashim et al., 2025). It is currently a key process for firms to reconcile economic growth & environmental sustainability (Aljehani et al., 2024). Compared to traditional innovation, GI improves operational efficiency and advances long-term ecological and social goals, including resource preservation and emission reduction (Moslehpour et al., 2023). A recent empirical study shows that GI improves business reputation, market performance, and environmental consequences (Ahmed et al., 2023). Despite the documented interrelationships among KM and innovation (Aljehani et al., 2024), green

innovation and sustainability (Al Koliby et al., 2022b), empirical studies have not fully examined the pathway connecting KM processes to green innovation and business sustainability.

This research presented a mediation model that links green innovation to KM processes and corporate sustainability to bridge this theoretical and empirical gap. This approach assumes that successful knowledge management processes, knowledge production, sharing, and application, allow firms to use their intellectual capital to produce creative sustainability solutions. These procedures assist the company in developing dynamic learning skills to find environmental opportunities, apply green technologies, and restructure its working processes to be more environmentally friendly. Thus, green innovation dynamically converts knowledge into quantitative sustainability outcomes (Garcia-Perez et al., 2020a).

Based on the Resource-Based View (Barney, 1991) & Dynamic Capabilities Theory (DCT) (Dahlquist, 2021), investigation should be considered as an innovation-oriented sustainability with KMPs as its fundamental assets. The RBV underlines that intangible resources like knowledge and innovative talents are valuable, rare, inimitable, and nonexchangeable (VRIN) and provide long-term competitive advantage (Amui et al., 2017). DCT proposes that firms modify and upgrade these resources to be competitive in a changing environment. In this research, KMPs are the knowledge infrastructure, GI is the dynamic capability that transforms knowledge into eco-innovations, and BS is the result. Modern sustainability includes environmental, performance, economic, and social stability (Awan et al., 2018). The Dynamic Capabilities Theory framework considers environmental stewardship, social equality, and economic sustainability, making it a generalized approach of sustainability (Chen et al., 2020). Thus, sustainable enterprises should innovate to reduce environmental impact, benefit society, and ensure long-term profitability (Geiger et al., 2019). Information management can diffuse environmental information, encourage employee innovation, and promote continuous improvement (Dahlquist, 2021; Simanjuntak et al., 2023). Despite this theoretical possibility, there are few actual investigations on GI's involvement in the KM-BS interaction, especially in emerging nations with underdeveloped environmental regulations and technology infrastructures (Deng et al., 2023). Most knowledge management and sustainability studies have focused on developed economies, where institutional frameworks and technical readiness differ from emerging economies. This contextual gap underscores the need to research whether and how KMPs might enable GI and improve sustainability in constrained resource and environmentally concerned settings (Szabo and Webster, 2021). Many firms deploy Knowledge Management systems, but few integrate environmental goals into their knowledge strategies (Wan and Du, 2022). For instance, institutions may contain enormous archives of technical information but fail to apply it to green innovations due to poor knowledge exchange or environmental neglect (Simanjuntak et al., 2023). Knowledge management and green innovation are linked by company culture, leadership commitment, and involvement (Al Koliby et al., 2022b). However, the delicate association among these aspects affects how much knowledge is transformed into sustainable solutions to increase sustainability performance.

A three-part study contribution. It builds on the literature by empirically establishing GI's mediation role between KMPs and BS, which would better explain how knowledge-based capabilities affect sustainability outcomes. Second, it combines RBV and DCT into a single theory to describe how knowledge becomes a lasting competitive advantage. Third, the study emphasizes aligning knowledge management techniques & green innovation goals for long-term sustainability. Organizations with excellent knowledge management processes and an innovation-driven culture can better respond to environmental issues, increase stakeholder confidence, and achieve strategic resilience. The study concludes that knowledge management methods spur green innovation, keeping organizations afloat. An actual examination of this mediation model revealed how intellectual capital and sustainability performance are related. The results should contribute to the theoretical discussion of sustainability-oriented knowledge management and provide practitioners who seek to incorporate sustainability into their businesses with useful recommendations.

2 Literature Reviews

2.1 Knowledge Management Process (KMP)

KMP is the method that businesses implement to collect, evaluate, and disseminate information throughout their organizations. KMP is the mechanism that businesses implement to gather, analyze, and disseminate information within their own organizations. The process of knowledge management could be a structured procedure that businesses follow to design, acquire, disseminate, and utilize information in order to improve their performance, innovation, and competitive advantage. Knowledge management is defined by Wang et al. (2019) as a process that allows for the acquisition, distribution, and utilization of knowledge. The primary goal is to transform individual expertise into organizational knowledge. In the same vein, Geiger et al. (2019) define it as the capacity of an organization to produce new knowledge, disseminate it throughout the organization, and incorporate it into its products, services, and systems. According to Yu et al. (2022), it typically comprises four important processes, which are the creation of knowledge, the storage of knowledge, the sharing of knowledge, and the application of knowledge. Knowledge acquisition entails new understanding through interactions, experience, or innovation; storage can guarantee that valuable knowledge is recorded and can be accessed when it is needed; sharing can help to provide communication and cooperation between different departments, and application helps to utilize the knowledge to address issues or enhance processes. According to Bag et al.'s (2020) study. Knowledge management technique boosts the learning potential of an organization, as well as decision-making and sustained innovation. This is because tacit & explicit knowledge are not only operated efficiently, but are also included in the strategies of the business.

2.1.2 SP

Sustainability performance discusses organization capacity for long-term economic success. Sustainability also maintains environmental stewardship & social responsibility. It embodies the concept of triple-bottom-line, i.e., economic, environmental, & social, asserting that a corporation's true success encompasses not just financial achievement but also its beneficial impact on society and the environment (Amui et al., 2017). Awan et al. (2018) define it as a contributor to sustainable development by integrating economic prosperity, environmental quality, and social equity within an organization. Srouji et al. (2023) regard performance as the result of managing environmental and social factors alongside economic competitiveness. Sustainability performance pertains to profitability, resource efficiency, environmental mitigation, and social well-being. Organizations that perform in these dimensions are likely to gain the trust of their stakeholders, foster innovation, and achieve market sustainability (Gulzar et al., 2024). In today's ESG-oriented environment, sustainability performance has emerged as a strategic imperative, reflecting the firm's ability to reconcile profit with responsibility while creating enduring value for both the business and society.

2.1.3 Green Innovation

Eco-innovation is the creation and application of new products, processes, services, and management methods that reduce environmental impact and improve organizational performance and competitiveness. It involves using new processes, techniques, systems, and products to reduce environmental risks, pollution, and resource use impacts (Hashim et al., 2025). Green innovation integrates ecological responsibility with technical and managerial progress to benefit enterprises and society. It has three dimensions: green product, process, and managerial innovation. Ahmed et al. (2023b). Green product innovation creates resource-saving and recyclable products; green process innovation reduces waste, emissions, and energy consumption in production; and green managerial innovation integrates environmental factors into management systems and strategic decision-making. These characteristics aim to boost environmental performance, operational efficiency, and competitiveness (Yu et al., 2022). Green innovation is a strategic move to meet consumer demand for green companies, comply with environmental regulations, and access green financing opportunities. Firms would take a proactive approach to pollution

control. Empirical studies show that green product and process innovation improves competitiveness and customer satisfaction, and Ahmed et al. (2023b) found that companies that adopt green innovation have the best sustainability and profitability. As global regulation pressures and environmental consciousness have increased, green innovation has become essential to resilience, reputation, and regulatory compliance. Finally, profit maximization should be replaced with sustainable value creation, which involves incorporating ecological risks in innovation processes to align stakeholders, build trust, and move toward a circular and sustainable economy.

2.3 Hypothesis Development

2.3.1 KA and SP

The process of knowledge acquisition is an essential component of the knowledge management process. It helps businesses to collect, integrate, and make use of knowledge derived from both internal and external sources in order to improve their decision-making and performance (Al Koliby et al., 2022a). According to Chen et al.'s (2020) research, it is a comprehensive process that involves the systematic collection of insights, expertise, and information from employees, customers, competitors, suppliers, and research institutions in order to develop strategic and operational skills. Knowledge acquisition is a crucial enabler for organizations to recognize new environmental trends, technological advances, and regulatory frameworks that directly influence sustainability performance (Garcia-Perez et al., 2020a). This is because knowledge acquisition serves as a fundamental enabler in the context of sustainability. In order to apply eco-efficient technologies, optimize resources, reduce waste, and limit their environmental footprint, businesses that actively learn information linked to sustainability are better suited to do so (Dahlquist, 2021). Furthermore, such information helps to facilitate the incorporation of sustainability into corporate strategy and organizational culture, which in turn promotes alignment with the triple bottom line, which consists of economic prosperity, environmental integrity, and social equality (Yu et al., 2022). According to studies conducted by Siyal et al. (2021), empirical data revealed acquisition of information encourages innovation that is driven by sustainability. This is accomplished by facilitating continuous learning and creative problem-solving in relation to environmental management. According to Kim and Stepchenkova's research from 2020, businesses that make an effort to gather and assimilate a wide range of information, ranging from environmental legislation to the expectations of stakeholders, are more likely to generate new green products and sustainable solutions, hence improving both resource efficiency and brand reputation. Furthermore, the process enhances a company's ability for adaptation, which enables the company to successfully react to quick changes in both the market and the environment (Putri et al., 2021). In a strategic sense, the acquisition of knowledge helps to establish dynamic capacities that are focused on sustainability and that link intellectual resources with long-term environmental and social goals. There is a direct relationship between knowledge of renewable energy systems, waste management, and sustainable supply chain methods, and higher performance concerning sustainability. According to Su and Li (2024), a structured and continuous knowledge acquisition framework not only promotes sustainable innovation but also enhances the resilience and competitiveness of an organization under resource-scarce conditions. It is also considered a building block to develop sustainable competencies that ensure long-term value creation, stakeholder trust, and ethical corporate behavior. Knowledge acquisition is assumed to act as a foundation for these emerging competencies. It is, therefore, recommended that

H1: Knowledge acquisition positively influences sustainability Performance SP.

2.3.2 Knowledge sharing (KS) and sustainability Performance (SP)

According to Amui et al. (2017), "knowledge sharing" refers to the process whereby members of an organization share their resources, including knowledge, ideas, and experience, in pursuit of common objectives. Knowledge sharing aids in the distribution of best practices in terms of environmental stewardship, social responsibility, and economic efficiency that pertain to the sustainability of an organization. Those employees who have been actively and assiduously sharing their expertise regarding

environmentally friendly technologies, resource optimization, and sustainable processes, for instance, turn out to be better qualified to adopt and improve sustainability programs within their firms. Empirical studies have shown that effective information sharing enhances organizational learning, creativity, and flexibility required to achieve long-term sustainability objectives (Chen et al., 2020). For example, collaboration across functional lines, open channels of communication collectively facilitate the integration of sustainability into the core business strategy. Information sharing also helps reduce redundancies, improves decision-making, and accelerates the execution of environmentally responsible activities. From this theoretical and empirical background, it is rational to expect that those organizations that promote a culture of knowledge sharing will demonstrate superior performance in terms of sustainability. Thus, the hypothesis that follows is:

H2: Knowledge sharing influences sustainability performance.

2.5.3 Knowledge application & Sustainability performance

Organizations must apply learned, shared, and internalized information to improve decision-making, problem-solving, and operational effectiveness (Deng et al., 2023). Knowledge generation and sharing establish the framework for organizational learning, but application turns knowledge into results. Knowledge application helps organizations operationalize ESG insights into strategies, practices, and performance improvements for sustainability. Knowledge and action are crucial to an organization's sustainability performance, which includes environmental stewardship, social responsibility, and economic viability. Sustainability issues are complicated and require collaboration across functional areas and stakeholders. Energy-efficient technologies, sustainable supply chain operations, and employee behavior change may help reduce carbon emissions. Diversity and inclusion research, community engagement best practices, and ethical labor norms may help improve social sustainability. When organizations apply relevant information to their operations, they are more likely to create efficient resource-use systems, minimize waste, maintain regulatory compliance, and build stakeholder confidence, which improves sustainability performance. Research shows that firms with strong knowledge application capabilities can implement eco-innovations and sustainable practices, which improve environmental performance (Gazi et al., 2024). According to Amui et al. (2017), knowledge that is applied through structured processes like green procurement policies (e.g., ISO 14001 standard), or sustainability training programs improves sustainability metrics. Knowledge application also improves organizational agility to address environmental issues and stakeholder expectations. Today's regulatory and consumer landscape is rapidly changing, so organizations that can quickly use lessons from past initiatives or external benchmarks can adapt and flourish in sustainability. This dynamic capability allows organizations to integrate sustainability into their business model rather than just complying with it (Amui et al., 2017). Based on theoretical and empirical evidence, firms that effectively apply knowledge would perform better in sustainability. Hence,

H3: Knowledge application positively influences SP.

2.5.4 GI, KA, and SP

The knowledge acquisition process involves internal & external information collection, insights, and expertise by organizations, acts as a crucial facilitator of strategic renewal and competitive advantage, especially in the area of sustainability (Gazi et al., 2024). Nonetheless, simply gathering knowledge does not inherently lead to enhanced sustainable performance; its true worth is unlocked when this knowledge is transformed into practical innovations that tackle environmental and social issues. Green innovation refers to the creation and application of new or notably enhanced products, processes, technologies, or organizational methods that provide environmental advantages while ensuring economic sustainability (Amui et al., 2017). It serves as an essential channel through which gained knowledge impacts sustainability results. Organizations that actively seek knowledge from sources like R&D collaborations, industry benchmarks, sustainability reports, academic research, or stakeholder feedback obtain valuable

insights into eco-design, circular economy principles, clean technologies, and regulatory trends. Through the transformation of acquired knowledge into green innovations, firms realize significant advancements in resource efficiency, waste reduction, carbon footprint mitigation, and social responsibility, essential aspects of sustainable performance. Empirical evidence supports this mediating role; studies indicate that firms with high levels of external knowledge acquisition frequently demonstrate enhanced green innovation capabilities, which subsequently result in improved environmental and economic performance (Srouji et al., 2023). For example, a manufacturing company that gains insights into biodegradable materials could create a new product line utilizing sustainable inputs, leading to green product innovation. This approach not only minimizes environmental impact but also boosts brand reputation and market share. In the same vein, gaining insights into energy-efficient production methods can result in process innovations that reduce both operational costs and emissions at the same time. In the absence of green innovation as a crucial intermediary, the potential of acquired knowledge stays dormant and unlinked to tangible sustainability outcomes. Therefore, green innovation connects knowledge inputs with performance outcomes, transforming intellectual capital into actionable steps that enhance sustainability (Alghamdi et al., 2023). Based on this conceptual and empirical foundation, it is suggested:

H4: Green innovation mediates the relationship between knowledge acquisition and sustainable performance.

2.5.5 GI, knowledge sharing, and SP

Organizations could attain sustainable performance by inventing & implementing environmentally friendly products, processes, & practices through GI (Kraus et al., 2020b). It involves adopting creative solutions to reduce environmental impact, improve resource efficiency, and support long-term ecological and societal goals (Alam & Islam, 2021). Knowledge sharing, a key component of knowledge management, helps bring sustainability-related knowledge across organizational boundaries and promote green innovation (Rodriguez et al., 2022). Therefore, firms actively encourage employees to contribute thoughts on environmental concerns, regulatory compliance, eco-efficient technology, and stakeholder expectations, creating an enabling atmosphere for green innovation co-creation (Aledo-Ruiz et al., 2022). Sustainable product designs, energy-efficient production processes, green supply chain practices, and waste reduction initiatives all boost sustainability performance (Solakis et al., 2022). Knowledge sharing helps organizations absorb and turn shared knowledge into green ideas, according to empirical research (Deng et al., 2023). Firms can find new environmental improvements and competitive differentiation in sustainable markets by combining internal and external stakeholder insights. Knowledge sharing promotes collaborative problem-solving and cross-functional integration, crucial for creating and implementing complex green solutions requiring coordination and expertise (Deng et al., 2023; Tønnessen et al., 2021). Green innovation mediates knowledge exchange advantages into sustainability outputs. Organizations that share knowledge on renewable energy, water efficiency, and low-emission materials can develop green innovations that reduce environmental impact, improve efficiency, and comply with regulations (Bulińska-Stangrecka & Bagieńska, 2021). The mediating role of green innovation is important since knowledge exchange does not inherently improve sustainability performance. Knowledge sharing raises awareness of sustainability concerns, but creative practices produce demonstrable environmental, social, and economic benefits (Bag et al., 2020). Green innovation turns shared knowledge into practical solutions that support organizational sustainability goals like reducing greenhouse gas emissions, waste, natural resource conservation, and social responsibility (Hashim et al., 2025). Organizations that use knowledge sharing to promote green innovation often gain long-term competitive advantages like improved reputation, stakeholder trust, and market differentiation, which reinforce sustainable business practices (Aljehani et al., 2024). Strategic knowledge sharing and green innovation enable organizations to learn from and adapt to the changing environmental regulations, stakeholder pressures, and technological advances (Ahmed et al., 2023b). Fostering an inventive culture of sharing and applying environmental

knowledge will help organizations improve their sustainability performance and adjust to the constantly evolving market conditions. Therefore, green innovation results in long-term creation of ecological and economic value and in improved sustainability performance through knowledge sharing. Thus, we hypothesized:

H5: GI mediates the relationship between knowledge sharing and SP.

2.5.6 Green Innovation, Knowledge Application, and Sustainability Performance

Knowledge application-the deliberate and effective use of organizational knowledge to solve problems, improve processes, and create value-drives strategic objectives, especially sustainability (Yu et al., 2022). While knowledge acquisition and sharing provide the raw material for innovation, applying this knowledge drives meaningful change in organizations. Ensuring business sustainability requires active implementation of solutions based on applied knowledge to make it viable, environmentally accountable, and socially equitable. Green innovation is instrumental in applying knowledge for sustainable business outcomes (Garcia-Perez et al., 2020b). Most firms have been seen to apply energy efficiency, waste reduction, sustainable sourcing, or eco-design knowledge to develop new green goods, optimize operations, or rethink business models that reduce environmental impact while increasing profitability. Turning knowledge into actionable green solutions enables organizations to meet sustainability objectives, stakeholder expectations, legislation, and be at a competitive advantage. Empirical evidence reveals that those firms that apply environmental and operational knowledge are more likely to create green innovations that help improve resource productivity, cost savings, brand differentiation, and resilience (Bag et al., 2020). A company using lean manufacturing principles and circular economy practices could come up with a closed-loop production system that reduces raw material use and waste, thereby improving environmental performance and long-term cost efficiency. Knowledge application may be confined to modest modifications of operations that fail to enhance sustainability in the absence of green innovation (Srouji et al., 2023). Green innovation transforms deliberate knowledge application into corporate sustainability outcomes as a strategic bridge. Therefore, a hypothesis is advanced:

H6: GI mediates knowledge application and SP.

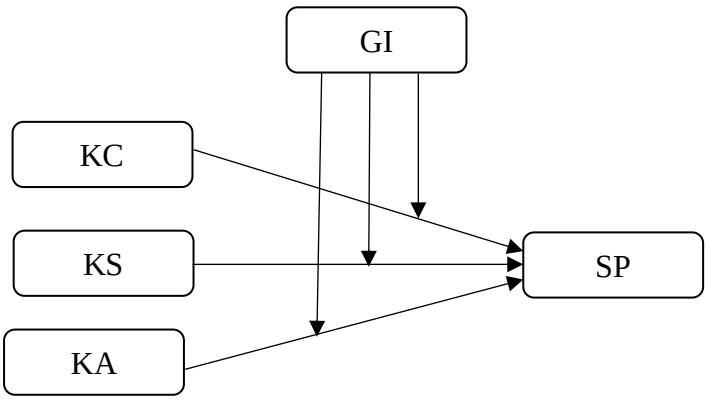

Figure 1: Conceptual Framework

3. Methodology

3.1 Research Design:

The research design adopted was descriptive correlational. The statistical population consisted of all technology-oriented businesses operating in major Pakistani cities, including Karachi, Lahore, Islamabad, and Peshawar, as of April 2024. The population consisted of 537 firms that had been actively engaged in software development and related digital fields for at least five years. These were identified by an official

annual registry of active enterprises published by the National Incubation Centers and Technology Parks of Pakistan. The responding organizations consisted of digital startups, which were defined according to national criteria concerning innovation-driven enterprises. Primarily private in nature, these were established to design, experiment with, and market the outcomes of their research and development activities concerning state-of-the-art technologies. Simultaneously, such organizations also established links between academia, industry, and government to facilitate the growth of a knowledge-based economy. Because the organizations were spread over large geographical distances, and there were problems of physical access during the COVID-19 pandemic, a simple random sampling method was used. Sample size was determined through Cochran's formula. Accordingly, the target sample consisted of 224 R&D employees. This proved to be adequate based on the threshold recommended in using SEM, which considers the sample size to be five to ten times the number of items in the questionnaire. Data were collected by using a 25-item, closed-ended, structured questionnaire related to knowledge management. Fifteen items: Social media use and business sustainability. Five items overlapped, used in both online and physical questionnaires. Responses employed a five-point Likert scale, where options ranged from strongly disagreeing to strongly agreeing. The inter-relationships between the constructs were evaluated using partial least squares structural equation modeling (PLS-SEM) on Smart-PLS 3, a statistical tool selected due to its resistance to non-normal data distribution.

3.1 Measurement Validity

In this study, knowledge management was the independent variable, business sustainability the dependent variable, and social media the mediating variable. The psychometric properties of the questionnaire were tested for validity and reliability to ensure accuracy and robustness. Content and construct measures were used to determine the validity. Subject matter experts and professors examined the content validity of measures. Construct validity was examined via SEM and discriminant validity tests. All constructs revealed AVE values above 0.5, which indicated convergent validity. Moreover, the AVE square root for each concept was greater over inter-construct correlations, which proved discriminant validity.

Cronbach's alpha & composite reliability were measured. The Cronbach's alpha for the instrument was 0.85, indicating good internal consistency, and all the constructs were above 0.7. Composite reliability results also came out to be above the standard threshold of 0.7, thus confirming measurement model dependability. Each of the concepts is unique to represent variation that was confirmed by having the square roots of the AVEs consistently bigger than the off-diagonal correlations in the latent variable correlation matrix. The findings confirm that the questionnaire was appropriate and reliable for the study.

Table 1: Reliability & Validity

	Items	CR	AVE	Cronbach's Alpha
KT	KT1–KT10	0.877	0.59	0.824
KA	KA1–KA5	0.883	0.612	0.831
GI	GI1–G5	0.894	0.629	0.852
BS	BS1–BS5	0.852	0.54	0.794
KC	KC1–KC5	0.895	0.632	0.854

Table 2: Discriminant Validity

Variable	1	2	3	4	5
KT	(0.872)				
KA	0.858	(0.881)			
GI	0.818	0.769	(0.854)		
BS	0.505	0.444	0.543	(0.735)	
KC	0.782	0.795	0.793	0.604	(0.868)

3.2 Measurement of Constructs

All dimensions were evaluated using multi-item questionnaires modified from existing work and a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Scales from (Gold et al., 2001) and (Chen & Huang, 2009) analyzed organizational routines for knowledge collection, sharing, and application. Based on Chen & Deng (2016) and Rennings (2000), green product, process, and management innovation was measured. Sustainability Environmental performance (waste reduction), economic resilience (cost efficiency), and social responsibility (community participation) were operationalized using the Triple Bottom Line (TBL) paradigm (Elkington, 1997).

3.4 Data Analysis Technique

SmartPLS 4.0 was used to do data analysis; this software was chosen because of its ability to represent complex models. This was investigated in two phases. Initially, the measurement model was validated using confirmatory factor analysis (CFA) to ensure reliability (alpha a > 0.7, composite reliability > 0.8), convergent validity (AVE > 0.5), and discriminant validity (HTMT < 0.85). The second step of structural model assessments included Path coefficients, R^2 values, and bootstrapping (5,000 resamples) to evaluate hypotheses and quantify direct and indirect effects.

4. Results

4.1 Demographic Analysis

The proportion of male and female participants among the participants was 53.12% and 46.88% respectively. In terms of age, 30.9% were below 35 years, 63.17% were between 35 and 45 years, 17.53 as were aged 45-55 years, and 10.0% were above 55 years. Regarding work experience, 34.88% had less than 10 years, 43.84% had between 10-20 years, and 17.70% had between 20-30 years' work experience.

4.2. Inferential Statistics

The model was tested with respect to three levels that included measurement, structural, and overall fit. The partial least squares method was applied to evaluate structural model fit based on several criteria. The first and the most basic one is the significance coefficient or t-statistic. The t-statistic is used to determine the fit of the structural model with the coefficients having to be greater than 1.96 to be deemed statistically significant at the 95 percent confidence level (Hair et al., 2017). The findings indicated that values that were more than 1.96 in critical value at the 95% confidence level were verified.

4.3 Coefficient of Determination

The second criterion used to evaluate the fit of the structural model is the R^2 coefficients for the latent endogenous variables. This criterion assesses the strength of relationships between constructs and applies only to dependent constructs, not independent ones. R^2 values of 0.19, 0.33, and 0.67 correspond to weak, moderate, and strong relationships, respectively. In this study, the R^2 values for social media and business sustainability were 0.754 and 0.387, indicating a good fit of the structural model based on this criterion.

4.4. Predictive Relevance (Q2)

The Q2 criterion is calculated by multiplying the values of the combined research constructs by their R2 scores. This criterion indicates how the model predicts the dependent variables. According to Kline (2015), in a model, the interactions between constructs are effectively created; hence, when the constructs

are adequately defined, they can effectively affect each other's indicators, appropriately confirming the hypotheses. All endogenous constructs have values of 0.2, 0.15, and 0.35, indicating low, moderate, and strong predictive power, respectively (Hair et al., 2017). This study reported Q2 values for corporate sustainability and social media of 0.320 and 0.645, respectively, indicating that the structural model fit well and was acceptable.

4.5 Model Fit

The overall model includes measurement & structural components, and its fit has been fully confirmed. The goodness-of-fit (GOF) index is used to assess the model's overall fit. With thresholds of 0.01, 0.25, and 0.36 indicating weak, moderate, and strong GOF, respectively, a value of 0.698 for this criterion demonstrates a strong fit for the research model.

The formula for GOF is:

$$GOF = \sqrt{average(Commonality) \times average(R^2)} \quad (1)$$

Another important indicator is the SRMR. Bayern (2005) indicated that a 0.05 value, or less than 0.10 as indicated by some studies, suggests model fit. Hence, the SRMR value falls within an acceptable range, confirming the model fits well (Table 3). Additionally, the Normed Fit Index (NFI) was used, with an accepted range of 0 to 1, and a value greater than 0.9. The NFI value here is 0.901, which meets the acceptance threshold.

Table 3: Goodness of Fit Indices

Index	Acceptable Value	Calculated Value
SRMR	≤ 0.10	0.010
NFI	≥ 0.9	0.957

To assess social media mediating impact, the Sobel test was conducted. So, Variance Accounted for (VAF) is calculated as follows:

Where:

- (a) Independent and mediator coefficient = 0.301; (b) Mediator and dependent coefficient = 0.149.
- The coefficients for the independent and dependent variables are 0.277, the standard errors for the independent and mediator variables are 0.073, and the standard errors for the mediator and dependent variables are 0.061.

The Sobel test statistic result of 2.057, which surpasses the baseline threshold of 1.96, suggests social media mediates the model. The VAF statistic of 0.139 implies that social media mediates slightly. Indeed, the proposed model fits both measurement and structural models.

4.6 Hypothesis Testing

The hypothetical relations among variables are analyzed via the t-statistic. Furthermore, six sub-hypotheses were created & examined. The t-statistic was used to prove six of these relationships, as indicated in Table 4. However, to determine the strength of the effect of the predictor variables on the dependent variables, the standardized factor loading coefficients of each hypothesis were examined. These coefficients mean the percentage of variation that is covered in the dependent variables by the independent variables.

Table 4 Hypothesis Testing

Hypothesis	t-statistic	β	Conclusion
H1	2.711	0.183	Supported
H2	0.65	0.082	Not Supported
H3	2.759	0.023	Supported
H4	3.987	0.25	Supported
H5	2.001	0.625	Supported
H6	20.57	0.57	Supported

5. Discussion

The first hypothesis argues that Generative AI will immediately improve sustainable supply chain performance. Based on several studies, especially generative models in AI technologies, it enhances supply chain management through decision-making optimization, resource allocation, and inefficiencies that come with more sustainable practices. Bulińska-Stangrecka & Bagieńska (2021) discovered that Generative AI enhances supply chain performance due to its optimization of resource use, lessening waste, and increasing sustainability.

The second idea presented is that Generative AI enhances the performance of the supply chain because it empowers sustainability. As various research indicates, AI technology enables green practices such as green purchasing, manufacturing, and eco-design, which enhance supply chain environmental and economic performance. González-Viralta et al. (2023) proved that AI enables integration with sustainable practices and enhances supply chain performance by reducing environmental impact while increasing efficiency.

The third hypothesis discusses Generative AI and green buying. Some studies indicate that AI enhances green purchasing decisions by enhancing supplier sustainability insights and procurement procedures. For instance, Alam & Islam (2021) and Xu et al. (2025) reported that AI systems help organizations make sustainable purchasing decisions that enhance the performance of supply chains while minimizing environmental impacts.

Hypothesis Four: The application of Generative AI will be linked to sustainable supply chain performance through green manufacturing. Kraus et al. (2020b) note that AI technologies can enhance product design, energy consumption, and waste reduction in manufacturing. AI for real-time data analysis and decision-making helps organizations apply greener ways of manufacturing, thereby enhancing the sustainability of the supply chain and its performance.

The fifth hypothesis deals with eco-design, where AI can enhance product lifetime analysis, material selection, and design optimization. In this regard, Park et al. (2017) and Amui et al. (2017) established that AI improves eco-design since it helps organizations reduce their environmental footprint from the outset. Introducing AI-driven insights into product development enhances supply chain performance and sustainability.

The fourth hypothesis deals with Generative AI and investment recovery in supply chains. Investment recovery, asset reuse, and recycling are all important components of supply chain circularity. Tønnessen et al. (2021) note that AI can improve investment recovery through better forecasting and the use of predictive analytics, considering the maximum value of any asset. Waste minimization and materials reutilization contribute to sustaining supply chain performance. These assumptions draw on literature showing AI's revolutionary potential to improve supply chain outcomes and sustainability.

5.1 Theoretical Implications

There are three key theoretical contributions in the study. Firstly, the study addresses a significant lacuna identified by prior studies (Shahzad et al., 2020; Fernando & Wah, 2017). This is achieved by integrating the knowledge management (KM), green innovation, and business sustainability literatures using a single mediation framework. The study bridges the gap that has existed between these theoretical areas of study by providing a full understanding of how knowledge management procedures can yield green innovation and improve sustainable business practices. This is achieved by merging these domains under consideration. Secondly, the study leverages RBV and DCT to position knowledge management processes as VRIN resources. In contrast, green innovation serves as a dynamic capability that converts knowledge into sustainable value. In this way, the study enhances how knowledge management (KM) evolves from a static resource to a strategic competency driven by innovation, which gives rise to a competitive advantage in sustainable business practices. Thirdly, the study provides evidence of the principle of full mediation, emphasizing that knowledge management procedures by themselves are not sufficient to achieve sustainability objectives. The application of such processes is only realized once they are channeled towards green innovation, which effectively unlocks their potential. These findings question prior studies that claimed direct associations between knowledge management and sustainability. This is because the finding herein indicates that it is essential to apply knowledge through innovation to achieve meaningful sustainability. It further contributes to the evolution of the written literature. These contributions taken together enhance our understanding of how knowledge management (KM), if channeled through innovation, can serve as a driver for sustainable business practices. They also offer a more nuanced understanding of the role that knowledge plays in fostering the sustainability of businesses.

5.2 Practical Implications

By underlining the issue that knowledge management alone is not capable of bringing in sustainability, the findings of this study provide practical insight that shall be useful to the managers of technology-driven enterprises, especially from emerging nations like Pakistan. The actual value of knowledge management is realized when it is utilized properly, specifically through platforms such as social media that have made it easier for people to collaborate and share their expertise. Managers should create a culture that will support knowledge development, transfer, and application by adopting digital tools, providing internal training, and offering open channels of communication with the employees. Social media should be used not only strategically for marketing but also as a collaborative platform in sharing knowledge internally and externally, since these are bound to drive innovation and responsiveness. Competitive advantage can be heightened, stakeholder trust can be created, and long-term resilience can be ensured by matching knowledge management techniques with sustainability objectives. Certain examples of such objectives include reducing environmental impact and increasing social responsibility. It is possible for managers to enhance organizational agility, improve reputation, and engender customer loyalty by incorporating sustainability into their knowledge management procedures. This will eventually result in the attainment of sustainable growth and success.

5.3 Limitations and Future Directions

There are a number of limitations that need to be considered for this study. First, the study has been based on cross-sectional survey data from R&D professionals working in Pakistani technology companies. This renders it difficult to make inferences about causal effects and to generalize findings to larger groups. Since the data was collected in a single moment in time, it misses the dynamic nature of the association that there is among knowledge management, environmentally conscious innovation, and sustainability. Secondly, reliance on self-reported measures contributes to common method bias, since participants could provide socially desirable responses, which may affect the accuracy of the data. Thirdly, the survey focuses most on urban centers like Karachi, Lahore, Islamabad, and Peshawar, at the expense of rural or informal tech ecosystems that may have different practices and challenges. The approach also views social

media as a uniform construct; it makes no differentiation between social media platforms like LinkedIn and WhatsApp, as these might play different roles in information sharing and may yield differing results in terms of overall effectiveness against one another.

When it comes to future research, the adoption of longitudinal or mixed-method designs would allow the researchers to monitor the development of knowledge-sustainability links over time. This would provide a more in-depth understanding of the causal pathways through which knowledge management procedures link up with sustainability. The second essential thing would be investigating social media consequences that are distinctive for each platform, since different platforms may play different functions in information exchange. By way of example, professional networks like LinkedIn may allow formal information sharing, while WhatsApp enables communication that is more casual and in real-time. Thirdly, a more nuanced understanding of elements influencing the efficiency of knowledge management systems to drive sustainability could be obtained by investigating the role of moderating variables such as leadership style, digital literacy, or environmental restrictions. A further development entailed including directly within the model, green innovation as a driver of sustainability to enhance its explanatory capability and thus comprise a more complete understanding of the function it assumes in sustainable practices. Lastly, comparative studies between different regions-for example, Pakistan versus European firms-or sectors-for example, health technology versus fintech-would enhance the external validity of research and yield insights into the contextual factors affecting efficiency in knowledge management and innovation strategies for promoting sustainability.

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