The Impact of Green Knowledge Management on Green Performance: The Mediating Role of Green Innovation

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ABSTRACT

Sustainability and environmental protection have become major strategic issues for companies worldwide. Green knowledge management (GKM) is considered a strategic element that enables companies to collect, share, and apply green information to meet stakeholder requirements and promote sustainability. Similarly, green innovation (GI) is recognized as a key driver of improved environmental performance. While most studies have examined these concepts separately, this study aims to investigate the relationships between GKM, GI, and green performance (GP) within a unified analytical framework. Specifically, this study examines the direct and indirect relationships between GKM, GI, and GP, highlighting the mediating role of green innovation. To achieve the study objectives, a quantitative approach was adopted. Data were collected using a survey questionnaire administered to manufacturing companies in Tunisia. The data were analyzed using a structural equation model based on the PLS approach. The empirical results indicate that GKM has a positive and significant effect on both GI and GP. Furthermore, GI has a positive and significant effect on GP. Mediation analysis reveals that GI plays a significant mediating role in the relationship between GKM and GP. This study contributes to the existing literature by proposing a conceptual model that examines the relationship between GKM, GI, and GP in the context of developing countries. Unlike previous research, which has focused primarily on developed countries, this study provides insights into how GKM practices can influence green innovation and green performance in the context of an emerging country with its own cultural and institutional framework. From a managerial perspective, the results suggest that managers could consider GKM as a strategic investment capable of stimulating green innovation and enhancing the sustainable performance of their organizations.

Keywords : Green knowldge management (GKM), Green innovation (GI), Green performance(GP)

INTRODUCTION

In the face of growing environmental challenges and increasing demands for sustainable development, organizations are increasingly compelled to reassess their management practices and innovation strategies. Indeed, green knowledge management (GKM) has attracted the interest of several researchers as a key factor in improving green performance (He et al., 2024; Wang et al., 2022; Rasheed et al., 2023). GKM is widely recognized as a set of processes that enable the creation, acquisition, sharing, and application of ecological knowledge with the aim of improving environmental performance (Yu et al., 2022). Existing literature has shown that green knowledge management contributes positively to the adoption of sustainable practices and the improvement of environmental performance (Song et al., 2020; He et al., 2024). Nevertheless, despite its growing relevance, GKM remains an emerging concept, and the relationship between GKM and green performance (GP) has not yet been sufficiently explored in the existing literature (Wang et al., 2022; He et al., 2024). In this context, studies (Shahzad et al., 2022; Abbas and Sagsan, 2019) have found that GKM promotes the development of green innovation (GI) and that the two concepts are complementary in improving performance and maintaining a company's competitive advantage. Green innovation refers to a set of new

practices, such as the development of environmentally friendly products or processes, that protect the environment and contribute to the creation of a more sustainable economy (Xie et al., 2019).

Previous research demonstrates that GI is a crucial factor in improving green performance, particularly in terms of reducing greenhouse gas emissions, conserving natural resources, and reducing waste. Current literature indicates that most researchers have examined green innovation and green knowledge management separately, without integrating these variables into a unified conceptual framework. Only a few studies have investigated the interplay between these two concepts and their effects on environmental performance (Polas et al., 2023; Wang et al., 2022). Moreover, little emphasis has been placed on the mediating role of green innovation in the relationship between GKM and green performance (Abbas and Sagsan, 2019; Shahzad et al., 2022). Furthermore, empirical research on these relationships remains limited, particularly in developing countries (Zaid et al., 2018). To fill this gap, the current study aims to empirically examine the direct effect of GKM on GP, as well as the mediating role of GI in the relationship between GKM and GP.

Therefore, this study seeks to answer the following questions :

1. How does GKM affect GP and GI?

2. Does GI mediate the relationship between GKM and GP?

This paper is organized as follows. Section 2 presents the theoretical framework. Sections 3 and 4 describe the methodology and present the results, respectively. Sections 5 and 6 provide the discussion and conclusions.

Theoretical Framework and Development of Research Hypotheses

GKM and green performance

Recent literature has revealed that GKM can lead manufacturing firms toward sustainability. Knowledge management helps companies to create and apply green knowledge, which ultimately contributes to promoting sustainable practices across social, economic, and environmental dimensions. Rasheed et al. (2024) and Riva et al. (2021) mentioned that GKM enables employees to employ cognitive and analytical capabilities related to sustainability and environmental protection. By investing in green knowledge, companies can align their operations with environmental management practices such as waste reduction and resource consumption minimization (Farrukh et al., 2022). Shahzad et al. (2022) assert that all dimensions of KM, such as acquisition, dissemination, and application, are significantly related to green innovation and corporate sustainability performance.Thus, we propose the following hypothesis:

H1. GKM positively influences GP.

GKM and Green innovation

Some studies have revealed that green knowledge management is essential for companies embracing green innovation. Khan et al. (2024) conducted a study of 309 construction firms in Pakistan and found that GKM significantly contributes to improving green technology innovation within organizations. According to Song et al. (2020), a company's ability to successfully engage in environmental innovation and sustainable development depends significantly on the effective management of green knowledge. The study by Wang et al. (2022), conducted on service and manufacturing firms in Turkey, found that GKM processes significantly strengthen green innovation. Sahoo et al. (2022) showed that green knowledge acquisition significantly contributes to enhancing green knowledge management and fostering new eco-products and eco-processes. The authors further demonstrate that green technology innovation plays a mediating role between green knowledge management and corporate environmental performance. Therefore, we hypothesize that,

H2. GKM *positively influences* GI

Green innovation and green performance

Previous studies have suggested that GI is a key tool for achieving economic, social, and environmental benefits (Wang et al., 2022; Abbas and Sagsan, 2019). The main objectives of GI are to develop products and processes that address environmental issues (Michaelis et al., 2018; Li et al., 2017). Ahmed et al. (2022) mentioned that GI is likely to reduce the negative effects of company activities on the natural environment. Companies can gain several competitive advantages by supporting green technological innovation and green management innovation, such as enhanced customer loyalty and economic benefits (Rehman, 2021 ; Albort-Morant et al., 2016). Therefore, we hypothesize that,

H3. Green innovation positively influences green performance

The indirect effects of GKM on Green performance

Prior studies suggest that green performance (GP) can be enhanced through the effective management of green knowledge (Wang et al., 2022; Su et al., 2020). Shahzad et al. (2022) argue that green GKMplays a critical role in supporting organizations' environmental initiatives. However, the study by Jilani et al. (2020) reported no significant relationship between GKM and GP. In this context, the introduction of a mediating variable such as green innovation (GI) may help clarify the mechanism through which GKM influences GP. Existing literature indicates that GKM fosters a culture of green innovation (Khan et al., 2024; Sahoo et al., 2022). Furthermore, several studies have emphasized that green innovation plays a key role in improving environmental performance (Makhlouf et al., 2023). Specifically, Wang et al. (2022) and Abbas and Khan (2023) demonstrate that effective green knowledge management enables firms to develop green innovations, which in turn enhance their green performance. Hence, the following hypothesis is proposed:

H.4 GKM positively influences GP through GI.

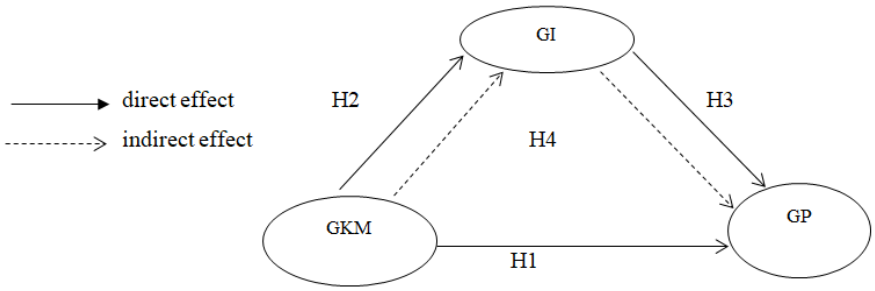

Figure 1. Conceptual model

RESEARCH METHODOLOGY

Sample and Data collection

The population studied consisted of Tunisian manufacturing companies. Data were collected using a questionnaire addressed to top management. A total of 215 questionnaires were distributed, of which 118 were returned completed. After data verification, questionnaires with missing data were excluded. Consequently, 103 usable questionnaires were retained for the study. The following table provides an overview of the respondents' characteristics.

Table 1. Respondent Demographic Profile

Particulars	Details	Number	Percentage %
Number of employees	<50	10	9.7
	50-199	25	24.27
	200-500	48	46.60
	More than 500	20	19.41

Gender	Female Male	5 98	4.85 95.15
Years of experience	Less than 5years 6 to 15 years 16 years or above	12 53 38	11.65 51.46 36.89

Measurement Scales

The items in the questionnaire were measured using a five-point Likert scale, with response options ranging from 1 ("strongly disagree") to 5 ("strongly agree"). GKM was measured by the extent to which its practices are used, namely green knowledge creation, acquisition, sharing, and application. Five items measuring each GKM practice variable were adopted from Yu et al. (2022). GI was represented by two dimensions, green product innovation and green process innovation, and four items for each dimension were adapted from Chen et al. (2006). Finally, five items measuring GP were adopted from Yu et al. (2017), Roscoe et al. (2019), and Singh et al. (2020).

RESULTS

Structural equation model (SEM) based on the PLS approach was used to analyse the collected data .

Measurement model assessment

Following the recommendations of Hair et al. (2018), Composite Reliability (CR) and Cronbach's Alpha were used to assess the reliability of the model. As shown in Table 1, the values for both measures surpassed the 0.70 threshold proposed by Hair et al. (2014), indicating satisfactory reliability. Model validity was examined by analyzing factor loadings along with convergent and discriminant validity. Table 1 confirms that all items had loadings above the recommended critical value of 0.70. In accordance with the guidelines of Fornell and Larcker (1981), the Average Variance Extracted (AVE) for each construct exceeded 0.50, ranging from 0.66 to 0.89, indicating satisfactory convergent validity. The results of convergent validity are presented in Table 1.

Table 2. Reliability and convergent validity analysis

Constructs	No. of items	Cronbach's Alpha	Factor Loading	Composite Reliability	AVE
Knowledge Creation	KC1	0.863	0.889	0.901	0.646
	KC2		0.844		
	KC3		0.842		
	KC4		0.905		
	KC5		0.708		
Knowledge Application	KAP1	0.844	0.750	0.891	0.623
	KAP2		0.757		
	KAP3		0735		
	KAP4		0901		
	KAP5		0.870		
Knowledge Acquisition	KA1	0.897	0.850	0.924	0.710
	KA2		0.869		
	KA3		0.903		
	KA4		0.851		
	KA5		0732		
Knowledge Sharing	KSH1	0.878	0.759	0.919	0.694
	KSH2		0.850		
	KSH3		0.826		
	KSH4		0.853		
	KSH 5		0.872		
	GPI1	0.902	0.872	0.926	0.757

Green product innovation	GPI2		0.876		
	GPI3		0.914		
	GPI4		0.887		
Green performance	GP1	0.870	0.781	0.906	0.658
	GP2		0.783		
	GP3		0.817		
	GP4		0.876		
	GP5		0.797		
Green process innovation	GPR1	0.808	0.789	0.874	0.635
	GPRI2		0.840		
	GPRI3		0.749		
	GPRI4		0.808		

Discriminant validity was assessed usiGng two methods: the Fornell and Larcker criterion and the Heterotrait–Monotrait ratio (HTMT), as proposed by Henseler et al. (2015). According to the Fornell and Larcker criterion, the square root of each construct's AVE should be greater than its correlations with other constructs. For the HTMT, values below 0.85 indicate adequate discriminant validity. The results, presented in Tables 3 and 4, confirm discriminant validity

Tableau 3. Fornelle-Larcker criterion analysis

	GPI	**GPRI**	**KA**	**KAP**	**KC**	**KSH**
GPI	0,870					
GPRI	0,309	0,797				
KA	0,205	0,421	0,843			
KAP	0,151	0,405	0,596	0,789		
KC	0,214	0,445	0,592	0,633	0,804	
KSH	0,207	0,446	0,529	0,644	0,757	0,833
GP	0,317	0,540	0,437	0,463	0,544	0,524

Notes : KAP = Knowledge Application ; KSH = Knowledge Sharing ; KA = Knowledge Acquisition ; KC = Knowledge Creation ; GPRI = Green Process Innovation ; GP = Green Performance ; GPI = Green Product Innovation.

Tableau 4. Heterotrait–Monotrait ratio (HTMT),

	GPI	**GPRI**	**KA**	**KAP**	**KC**	**KSH**	**GP**
GPI							
GPRI	0,322						
KA	0,222	0,498					
KAP	0,178	0,487	0,680				
KC	0,237	0,529	0,650	0,729			
KSH	0,236	0,525	0,591	0,738	0,853		
GP	0,337	0,642	0,492	0,537	0,620	0,594	

Structurel Model assessment

The structural model was evaluated by examining the significance of the path coefficients using the bootstrap technique. The explained variance of the endogenous variables was assessed using R^2 values, while the predictive relevance of the model was evaluated using Q^2. According to Chin et al. (1998), R^2 values of 0.26, 0.13, and 0.02 correspond to high, moderate, and low explanatory power, respectively. The R^2 value for GI was 0.395 and for GP was 0.157, indicating adequate predictive power of the model (Hair et al., 2016) . The results of the blindfolding procedure for Q^2 values were 0.354 for GI and 0.147 for GP, all of which are greater than zero, confirming the model's predictive relevance.

Table 5. Assesment of R^2 and Q^2

	R Square	**Q2**
GI	0. 259	0.156
GP	0.419	0.259

The direct and indirect relationships between , GI, GKM and CS were tested using Bootsrapping technique. The empirical results indicate that GKM has a positive and significant effect on GP ($\beta = 0.414$, $T = 4.412$, $p < 0.001$), supporting Hypothesis 1. GKM also shows a positive and significant relationship with GI ($\beta = 0.509$, $T = 6.988$, $p < 0.001$), supporting Hypothesis 2. In addition, GI positively and significantly influences GP ($\beta = 0.330$, $T = 3.149$, $p < 0.01$), confirming Hypothesis 3. Furthermore, the mediating role of GI in the relationship between GKM and GP is supported. GKM exerts a positive and significant indirect effect on GP through GI ($\beta = 0.168$, $T = 2.729$, $p < 0.01$), thereby confirming Hypothesis 4.

Table 6. Hypothesis testing.

	Hypothesis	**Constructs**	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**	**Hypothesis Decision**
Direct effect	H1	GKM ⟶ GP	0,414	0,411	0,092	4 .412	**0,000**	Accepted
	H2	GKM ⟶ GI	0,509	0,509	0,073	6.988	**0,000**	Accepted
	H3	GI ⟶ GP	0,330	0,339	0.105	3.149	**0,003**	Accepted
Indirect effect	H4	GKM ➔ GI ➔ GP	0,168	0,173	0,062	2.729	**0,006**	Partial Mediation

DISCUSSION

The current study aimed to analyze the direct and indirect effects among green innovation, green knowledge management and green performance within a single analytical framework. The results reveal a positive association between GKM and GP. This finding corroborates the studies of Wang et al. (2022) and Abbas and Sağsan (2019), which confirm that green performance can be achieved through effective green knowledge management. This highlights that GKM constitutes a strategic lever for strengthening green performance. Similarly, the findings indicate a positive effect of GKM on GI, and these results are consistent with those of Nazarian et al. (2024), who identified GKM as a significant predictor of green innovation. This suggests that the systematic acquisition, sharing, and application of ecological knowledge promotes green innovation within organizations. The results also suggest that GI has a positive effect on GP. These findings are consistent with those of Bouzabia and Ben Salim (2023), who demonstrated that GI positively affects green performance in the context of Tunisian manufacturing companies. The results of this study indicate that the adoption of green products and green processes constitutes a genuine lever for improving green performance. This encourages managers to consider green innovation as a strategic tool for enhancing environmental outcomes, as it helps companies reduce emissions and minimize the inefficient use of resources.

Finally, the results indicate that green innovation partially mediates the relationship between green knowledge management and green. This finding is consistent with the work of Abbas and Khan (2023) and Shahzad et al. (2022), who show that knowledge management has an indirect effect on corporate sustainability through green innovation in the context of Pakistani manufacturing companies. These results suggest that effective green knowledge management enables companies to develop green innovations, which in turn enhance their green performance.

CONCLUSION

The objective of this study is to empirically examine the relationships among green knowledge management, green innovation, and green performance in the context of Tunisian manufacturing companies. The hypotheses were tested using structural equation modeling based on partial least squares (PLS-SEM). The results indicate that GKM has a direct effect on both green innovation and green performance. Additionally, the findings show that green innovation partially mediates the relationship between GKM and GP.

Theoretical Implications

This study contributes to the existing literature by analyzing both the direct and indirect relationships among GKM, GI, and GP in the context of an emerging country. Most previous studies have examined these three concepts in isolation. Furthermore, this study emphasizes the mediating role of green innovation in the relationship between GKM and GP. Finally, it provides empirical evidence from an emerging country context namely Tunisia which has been relatively underexplored in the literature.

Managerial Implications

The findings of the current study have several managerial implications. First, the results indicate that green knowledge management (GKM) has a direct effect on green performance (GP). This suggests that managers should effectively leverage ecological knowledge to reduce the negative environmental impacts of their operations and ensure compliance with environmental regulations. Second, the findings reveal a positive relationship between GKM and green innovation (GI), indicating that managers should view GKM as a key tool for promoting the acquisition, sharing, and application of environmental knowledge to enhance green innovation. Finally, the results underscore the mediating role of green innovation in the relationship between GKM and GP. In this regard, managers are encouraged to foster green innovation as a strategic mechanism that transforms environmental knowledge into concrete actions to improve the company's environmental performance.

Limitations and Future Perspectives

The present study has some limitations. First, the study sample is limited, which may affect the generalizability of the results. Therefore, it would be advisable for future research to extend the analysis to other sectors or industries. Second, the data were collected using a cross-sectional design ; future studies could adopt a longitudinal approach to examine how these relationships evolve over time. Finally, contextual factors that may influence the relationship between green knowledge management, green innovation, and green performance could be explored in future research.

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