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Antecedents to foster green innovation: The role of green HRM, knowledge management and organizational culture

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Abstract: Due to the important role of green innovation in helping firms achieve sustainable development, environmental protection, and a competitive advantage, this paper aims to investigate the influence of green human resource management (HRM) practices on green innovation through the mediating roles of green knowledge management (KM). This study also explores the potential moderating role of green culture in fostering the influence of green KM on aspects of green innovation, namely green product and green process innovation. The paper utilized a quantitative approach and Structural Equation Modeling to examine the relationships among the latent constructs using survey data collected from 305 participants across 118 firms. The empirical findings highlight the significant mediating role of green KM in linking the effects of green HRM practices to green product and process innovation. It also supports the moderating role of green culture in enhancing the influence of green KM on aspects of green innovation. The paper provides CEOs and managers with a better understanding of appropriate solutions and approaches to enhance firms' green product and process innovation. Additionally, the paper contributes to advancing innovation theory by clarifying the antecedents and moderated-mediation effects in predicting green product and process innovation within the context of emerging markets.

Keywords: *Green culture, Green HRM, Green knowledge management, Green process innovation, Green product innovation.*

1. Introduction

In today's era of globalization, the challenge and the need for corporate sustainability is to simultaneously satisfy environmental concerns along with economic benefits [1, 2]. Green innovation (GI) is an inevitable option due to strict environmental laws and long-term production and consumption patterns. It allows firms to develop products and production processes that are less harmful to the environment, utilize less energy, are easily recyclable and use recycled materials [2, 3]. However, it is a challenge for firms in emerging and developing markets to become green innovators rather than imitators due to majority of them are medium and small size, with the lack of capital, resources and experience to invest in environment friendly practices to enhance their green innovation [4, 5]. Such situation has led researchers and practitioners to devote much effort to detecting the finer antecedents and new solutions to improve green innovation for firms in these nations [3, 6].

Scholars and practitioners are increasingly aware and paying attention to identifying appropriate solutions or strategies to help firms achieve environmental goals and improve organizational performance through pursuing green innovation [1, 7]. Green human resource management (HRM) and green knowledge management (KM) practices are considered an optimal choice for firms to strengthen their core competencies and improve green innovation [1, 5, 8]. As a result, to clarify the role of these potential factors, this study attempts to explore the influences of green HRM practices on

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green innovation via the mediating role of green KM practices. This study is expected to significantly expand the theory of HRM, knowledge management, and innovation management for many motives.

First, knowledge is a valuable intrinsic resource that plays a key role in the success or failure of any organization [9-11]). Better knowledge management allows a firm to become more competitive and efficient by virtue of its ability to access and utilize correct information and knowledge at the right time and in an adequate manner [12, 13]. Green HRM practices are generally accepted as the primary means for firms to shape and develop employees' green skills, attitudes, and behavior by which they can successfully implemented green innovation behavior and achieve organizational goals [14, 15]. Although there is a broad acknowledgement on the importance of HRM practices toward firm's outcomes such as productivity, flexibility, and organizational performance, little empirical research has been done for explaining the potential effects of green HRM practices on specific forms of green innovation such as green product and process innovation [3, 16, 17]. Accordingly, to address the research gaps on green HRM-innovation relationship, this study attempts to clarify the first research question: *Do green HRM practices significantly predict green product and process innovation?*

Second, literature have highlighted HRM practices as the key to promote knowledge management capability for enhancing innovation performance, the interaction of green HRM, KM and green innovation has rarely been empirically verified, and the landscape of this relationship has remained mostly undetermined [15, 18]. In addition, understanding of the mediating role of green KM in the relationship between antecedent factors and green innovation in terms of green product and process innovation is still very modest and limited [2, 3]. As a result, to bridge the theoretical gaps and provide deeper insight on the mediating roles of green KM in the relationship between green HRM practices and green innovation, this study poses the second research question: *Does green KM serve as a mediator in the green HRM-innovation relationship?*

Third, along with HRM and KM practices, the existing literature emphasizes the influence of organizational culture on a firm's innovation capability [19, 20]. Organizations with different cultural characteristics may have distinct effects on the relationship between KM capability and innovation due to differences in the provision of resources, opportunities, and motivations for innovation activities [21, 22]. In particular, previous studies have shown that KM processes and systems supported by an innovation culture are important for the success of innovation management [23, 24]. Therefore, to determine whether innovation culture will stimulate or hinder the impact of green KM on green innovations, this study will examine the possible moderating role of innovation culture in the relationship between green KM and two specific forms of green innovation. Accordingly, the third research question arises: *Does green culture moderate the influence of green KM on green product and process innovation?*

To address the above research gaps and questions, this study used Structural Equations Modeling to investigate the correlation among the constructs through a survey of 305 participants from 118 service and manufacturing firms in Vietnam. The paper is expected to provide significant practical implications and valuable theoretical initiatives on the roles of GHRM practices toward GKM and green innovation for organizations.

2. Literature Review and Hypotheses Development

2.1. The impact of Green HRM Practices on Green Innovation

Green HRM implies that firms integrate the concept of environmental management into the HRM process to fulfill the business's strategic environmental plans and boost its environmental performance [15]. Green HMP practices are considered as an inevitable choice in the environmental era enabling firms to obtain their green innovation and organizational performance since the human resource function plays a significant role in achieving eco-friendly corporate goals [18, 25]. According to Kramar [26], green HRM involves "HRM activities which enhance positive environmental outcomes" (p. 1075). It refers to the HRM aspects of green management applied to encourage pro-environment employee behaviors in the workplace [27]. Based on the available literature, the paper defines green HRM as the

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HRM model/practices to promote environmental sustainability and green performance objectives through recruiting employees based on green criteria; providing skills and environmental management training programs; evaluating performance based on employee sustainability performance and rewarding employees for eco-friendly initiatives and achieving green targets [18, 25, 28].

The increasing challenges and demands for environmental sustainability require human activities to be green and innovative to protect the environment. Green innovation extends from innovation and requires innovations in products, processes and/or management structures to be green [2, 29]. Green innovation is essential for firm's business management to create value, increase the organizational performance, and leverage a competitive advantage [30, 31]. According to Abbas and Khan [4] "green innovation refers to the introduction of significantly improved or new organizational products, processes, technologies or management systems that significantly decrease natural resource consumption, emission of toxic substances and the negative impact on the natural environment" (p. 1856). Green innovation requires firms to integrate green development goals into product and process development. Green product innovation refers to products that use fewer resources, reduce negative environmental impacts, and prevent waste generation during the product disposal phase [2, 32]. Green process innovation involves the adoption or exploitation of new or improved production processes that reduce environmental pollution compared to relevant alternatives [33].

Scholars have devoted much effort to investigate the influence of green HRM on green innovation [5, 15]. Many studies in the growing literature on HRM practices have shown the importance of HRM in enhancing employees' skills, knowledge, and abilities, thereby facilitating the innovation capability of firms [34, 35]. Accordingly, it can be argued that the adoption and implementation of firm's green HRM activities has a significant impact on green innovation. For example, recruiting and selecting employees with a green orientation not only encourages employees to demonstrate pro-environmental attitudes and behaviors but also actively participate in green innovation-related activities [36]. Employees with green values will enjoy working and devote themselves to helping firms be more innovative in presenting and implementing novel green ideas. Furthermore, recruiting employees with high levels of environmental sensitivity and ability can generate more novel and useful ideas to manage environmental issues and concerns, thereby enhancing the green innovation of firms [25]. Similarly, providing green training facilitates employees to acquire environmental management skills and knowledge, which promotes the generation of new ideas for green innovations [18, 37]. Finally, the appraisal of individual green contributions, rewards and promotions based on green performance could motivate green values and actions of employees to achieve green objectives and innovations [18, 25]. Therefore, green HRM activities can enhance employees' motivation, ability, and opportunity, thereby enhancing their unique knowledge of green process and product innovations. Current literature also provided empirical evidence and revealed that green HRM practices are positive and effective solutions for firms to succeed in pursuing green innovations [16, 25, 38]. However, there is still a lack of studies that explore the impact of green HRM on green innovation in terms of green product and green process innovation, accordingly, the following hypotheses are proposed:

H_{1a} Green HRM practices are significantly associated with green product innovation.

H_{1b} Green HRM practices are significantly associated with green process innovation.

2.2. Mediating Role of Green KM between green HRM Practices and Green Innovation

Green knowledge is about information about a natural condition and guides how to follow a more sustainable path of environmental, social and economic development [39]. In other words, it is more innovative and capable of exploring new sustainability paths. Since it is an intangible and valuable asset, researchers highlight the importance of managing green knowledge to help firms innovate, improve performance, create competitive advantage and benefit the natural environment [4, 13, 40].

Green KM is generally perceived as the firm's capabilities of acquiring, sharing, and applying green knowledge resources to generate core value, achieve organizational success while protecting the natural environment [36, 41]. In which, green knowledge acquisition refers to firms' capability of seeking,

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acquiring, extracting, and organizing knowledge relating to environmental protection [40]. Basically, employees acquire new knowledge from internal sources of firms like peers and team members, which helps them handle business-related issues and improve individual and organizational productivity [1]; green knowledge sharing involves firms' capability to foster processes of transferring or sharing green knowledge among employees to develop new methods, technologies, tools and techniques that effectively offset or mitigate the harmful impacts of business activities on the natural environment [40, 42]; and green knowledge application reflects a firm's ability to integrate green knowledge into decision making, design, or delivery of environmentally friendly products or services. By applying green knowledge, firms can introduce novel ideas, processes, and technologies to create competitive advantage [40, 43].

Previous studies indicated the significant effect of HRM practices on KM practices [44]. According to Jimenez-Jimenez and Sanz-Valle [45]. HRM practices are beneficial to KM capability by producing an appropriate climate to encourage processes of acquiring, supplementing and transferring knowledge among employees. Gope, et al. [46] advocated that the success of knowledge management processes mainly depends on the effectiveness of HRM activities in an organization. Their empirical findings revealed the significant effects of HRM practice on KM practices by their positive impacts on the motivation, retention, and behaviors of employees for acquiring and sharing knowledge. As argued by Al-Tal and Emeagwali [47]. HRM practices can be considered as a way of managing knowledge, thus it creates favorable conditions and opportunities to promote employees for sharing and applying knowledge in organizations. Iqbal, et al. [48] justified that HRM practices are beneficial to the formation of knowledge-oriented culture, informal learning, organizational infrastructure, administration and senior support and a proper system for knowledge transfer. Than et al. [49] stated that "employees are the main carriers and forces of knowledge capital in an organization, thus firms can apply HRM practices to enrich organizational knowledge resource by enhancing potency of activities of staffing, training, performance evaluation, and incentive compensation" (p. 89).

Regarding the green HRM-KM relationship, Zhang and Guo [50] asserted that green HRM activities help employees recognize the organization's environmental protection vision and green signals, thereby motivating employees to collect environmental information and enrich their knowledge of environmental protection. As noted by Rubel, et al. [18] green HRM promotes greater employee encouragement in sustainability behaviors, thereby increasing the likelihood of sharing and applying green knowledge to obtain green organizational objectives and maintain environmental sustainability. Recently, Miah, et al. [51] explained that green training, engagement and development are key elements of HRM practices for the development and reproduction of green knowledge including smart technology, artificial intelligence, robotics skills and useful algorithms to promote environmental goals. These empirical findings confirmed the positive effects of green HRM practices on environmental knowledge management. From these arguments, this study supposed that green HRM practices significantly create an organizational social climate that encourage the willingness of employees to acquire, share and apply their green knowledge for addressing environmental issues and the organization's green goals. Accordingly, this study hypotheses as follows:

H_2: Green HRM practices positively affect green KM.

Regarding green KM-green innovation relationship, numerous previous studies have shown the crucial influence of green KM on specific forms of green innovation. Wu [52] found that the key to green innovation success for organizations is to collect and promote the sharing of green knowledge and skills among employees in the organization. Qiu, et al. [53] noted that by sharing task-related skills and expertise with colleagues, KS process among employees might create a lot of opportunities to generate new ideas and enhance firm's innovation performance. According to Albort-Morant, et al. [29] knowledge-intensive organizations strive to maximize resource efficiency and operate environmentally responsibly. Therefore, they promote the creation of green product and process innovations and are continuously concerned with the environmental effect of their activities through green KM approaches to foster the development of new green knowledge [3, 54]. Abbas and Sağsan [54] claimed that green

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KM practice significantly predicts green innovation because it enhances individuals' pro-environmental learning orientation, leading to new knowledge for firms with new ideas, thoughts and solutions, ensuring ecological restoration. The KM processes of sharing and applying green knowledge enables firms to identify innovative methods that significantly enhance their green product and process innovation [3, 41]. The empirical studies of Wang, et al. [41] and Shehzad, et al. [3] support the positive impacts of green KM on green product and process innovation. In light of the above discussion on green KM and green innovation, this study argues that green KM practices make it possible for firms to create green product and process innovation based on using the least available resources, which benefits both the environment and the firm. In other words, green KM allows firm to avoid being constrained inside their knowledge boundaries, thereby creating opportunities to renew knowledge and foster green product and process innovation. So, the following hypotheses are put forth (Figure 1):

H_{3a}: Green KM practices are positively associated with green product innovation.

H_{3b}: Green KM practices are positively associated with green process innovation.

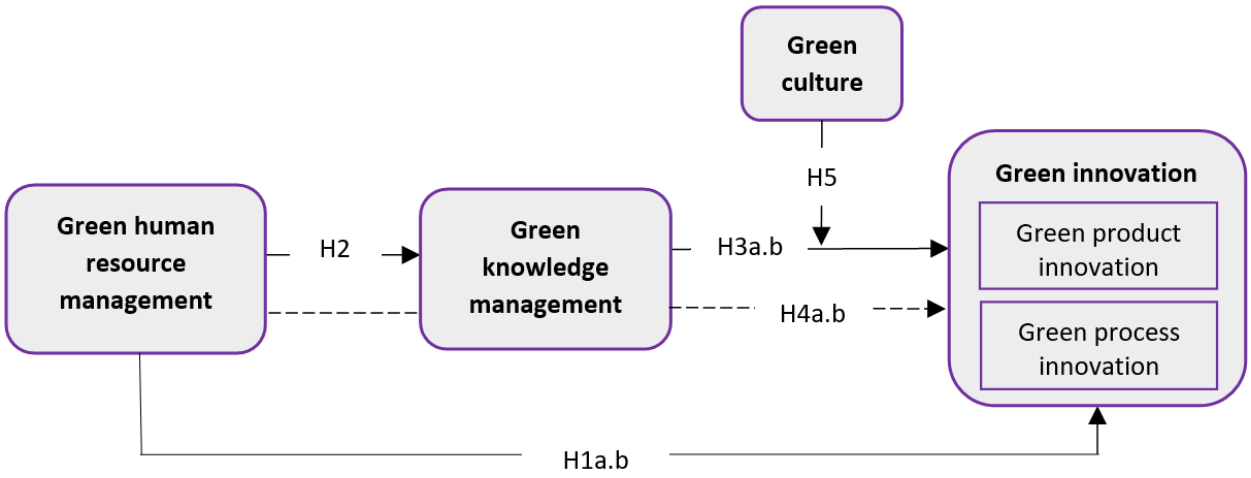

Figure 1.
Proposed research model.

Above arguments show the positive influence of GHRM practices on green KM, which in turn induces significant impacts on green innovations. Implicitly, green KM serves as a mediator in the relationship between green HRM practices and green innovations. Prior works also support the mediating role of green KM practices in bridging the effects of HRM practices on various forms of innovations. Rubel, et al. [18] demonstrated that influence of green HRM on green service behavior is potentially mediated by green knowledge sharing. Than, et al. [34] confirmed that firms can apply HRM practices to foster product and process innovation directly or indirectly via mediating role of KM practices. Specifically, Shehzad, et al. [3] highlight the mediating role of KM practices in the effects of KM enablers (such as knowledge-oriented leadership and green entrepreneurial orientation) on green product and process innovation. In line with these findings, this study proposed that:

H_{4a}: Green KM practices mediate green HRM and green product innovation.

H_{4b}: Green KM practices mediate green HRM and green process innovation

2.3. Moderating Role of Green Culture between Green KM and Green Innovation

An organization's green culture can be defined as a culture in which environmental protection is considered fundamental. Therefore, a core value of the company's employees is incorporated into the company's mission statement, making every team member feel responsible for protecting the environment [4, 41]. Motivated by the values and norms of green culture, employees are more

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concerned about environmental issues, which in turn positively impacts their efforts and behaviors in pursuing green innovation [41, 55].

Previous research has shown that organizational culture significantly moderates the impact of KM practices or organizational factors on innovation. For example, according to O'Regan, et al. [56] many firms face challenges in converting research and development into effective innovation. These authors found that companies with stronger cultures achieve higher product innovation. Of particular note, Donate and Guadamillas [57] pointed out the significant influence of organizational culture on KM capability and organizational innovation. These authors revealed that knowledge-centered culture can create a multiplier effect on the relationship between KM practices and innovation. Yang, et al. [58] emphasized that collaborative culture promotes activities of idea sharing, experimentation, exploration, and exploitation of organizational knowledge resources among employees, which is very beneficial for strengthening or supporting the aspects of innovation. Martins Marques de Lima Rua and Costa Araújo [59] and Ghasemzadeh, et al. [60] demonstrated that by focusing on a shared system of values, beliefs, and goals to encourage employee experimentation and innovation, firms can develop an innovation culture to enhance the impact of knowledge assets on innovation performance. Wang et al. [41] claim that being the boundary condition, green culture strengthens the relationship between green KM and green innovation. According to Abbas and Khan [4] green culture can enhance the effectiveness and adoption of green innovation when green KM is implemented, because it increases employees' concerns about sustainability. In case of deploying environmental knowledge in firms, organizational green culture will persuade employees to contribute to the realization of green innovation. Above arguments support moderating role of green culture between green KM and green innovation. To explore the possible moderating mechanism of green culture in the influence of KM practices on green product and process innovation, the following hypotheses are put forward:

H_{5a}: Green culture positively moderates the green KM-product innovation relationship.

H_{5b}: Green culture positively moderates the green KM-process innovation relationship.

3. Research Methodology

3.1. Sample and Data Collection

This study applied a quantitative methodology using empirical data collected from 118 service and manufacturing firms in Vietnam in June to August, 2024. These firms randomly selected from the list of nearly 250,000 enterprises in the yellow pages of the Vietnamese business directory in 2024. The authors communicated with representatives of the firms, who primarily works in human resource department to explain the purpose of the research, commit to information security for respondents, and ask for their help in distributing questionnaires and then collecting data. The respondents in each firm need to be key employees such as Directors, Vice-directors/managers, Heads of key departments (such as administration and R&D departments) to ensure them having a full understanding of the firm's business situation. The measurement items are used in this study adapted from existing scales in the literature to develop the initial list of items. Overall, this study issues 580 questionnaires and receives 472 ones in the formal data collection, among which 305 ones are valid, corresponding to a validity rate of 52.58%.

3.2. Variable Measurement

All items in this study have been developed by prior works that measured via five-point Likert-type scales ranging from "1" (strongly disagree) to "5" (strongly agree).

Green HRM practices. This study used six items adapted from the study of Dumont, et al. [61] to measure participants' perception of GHRM practices in their firms. A sample item is "Our firm provides employees with green training to promote green values".

Green KM practices. This study used five items adapted from the study of Sahoo, et al. [7] to measure green KM. A sample item is "Our firm has procedures in place to gain knowledge about the environmental practices of our competitors, suppliers, clients, and strategic partners".

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Green innovation. To measure green product and process innovation, this study adopted seven items green innovation scale consisting of four items for green product innovation and three items for green process innovation from Singh, et al. [62]. The sample items are "My firm uses materials that produce least pollution" and "The manufacturing processes of my firm effectively reduces use of raw materials".

Organizational green culture. This study used six items obtained from studies of Abbas and Khan [4] and Wang [63] to measure green culture of firms. A sample item is "Our firm makes a concerted effort to make every employee understand the importance of environmental preservation".

Control variables. This study examines the control roles of industry type to account for differences among firms due to their potential roles in affecting green innovation.

4. Data Analysis and Results

4.1. Measurement Model

This study first tested the reliability of the measures for the constructs by examining the private Cronbach's alpha coefficients (Cα). The results of statistics are range of 0.91 - 0.95, which are all over than Nunnally and Bernstein [64] recommended level of 0.7. We continuously analyze confirmatory factor (CFA) to evaluate the universal measurement model to check the discriminant and convergent validity (see Table 1).

Table 1.
Standardized loading and reliabilities for measurement model.

Construct	Item	Standardized loading	*t*-value	AVE	CR	Cα
Green HRM practices (GHRM)	6	-	-	0.66	0.92	0.92
	GHRM1	0.821***	17.35			
	GHRM2	0.836***	17.84			
	GHRM3	0.793***	16.46			
	GHRM4	0.839***	17.35			
	GHRM5	0.791***	16.40			
	GHRM6	0.817***	17.22			
Organizational green culture (OGC)	6	-	-	0.79	0.95	0.95
	OGC1	0.769***	19.98			
	OGC2	0.934***	38.33			
	OGC3	0.979***	53.40			
	OGC4	0.725***	17.64			
	OGC5	0.973***	53.40			
	OGC6	0.927***	36.70			
Green knowledge management (GKM)	5	-	-	0.67	0.91	0.91
	GKM1	0.849***	17.34			
	GKM2	0.837***	17.34			
	GKM3	0.812***	16.04			
	GKM4	0.800***	21.13			
	GKM5	0.794***	15.54			
Green product innovation (GPDI)	4	-	-	0.82	0.94	0.94
	GPDI1	0.888***	27.30			
	GPDI2	0.936***	32.83			
	GPDI3	0.951***	32.83			
	GPDI4	0.844***	23.57			
Green process innovation (GPCI)	3	-	-	0.82	0.93	0.93
	GPCI1	0.907***	28.42			
	GPCI2	0.847***	23.55			
	GPCI3	0.965***	28.42			

Note: Cα ≥ 0.7; CR ≥ 0.7; AVE ≥ 0.5; *** Significant at p<0.001.

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4.2. Convergent Validity

To get the measure of the convergent validity, results in Table 1 reported that all three main measurements meet the criteria on convergent validity recommended by Fornell and Larcker [65] specifically, factor loadings are range of 0.725 - 0.973; CR values are range of 0.91 - 0.95; and the AVE values are range of 0.66 - 0.82. Table 1 exhibits the standard deviation (SD), means, AVE, CR, factor loading, and Cα of all constructs.

4.3. Discriminant Validity

To assess the discriminant validity, according to Fornell and Larcker [65] criterion, the square root of the AVE for each construct should be greater than the correlation between constructs (see Table 2).

Table 2.
Descriptive statistics and construct correlations.

Constructs	**Mean**	**S.D.**	**GHRM**	**OGC**	**GKM**	**GPCI**	**GPCI**
Green HRM practices (GHRM)	3.40	0.54	**0.81**				
Organizational green culture (OGC)	3.57	0.51	0.36***	**0.88**			
Green knowledge management (GKM)	3.56	0.57	0.60***	0.39***	**0.82**		
Green product innovation (GPDI)	3.64	0.58	0.48***	0.40***	0.53***	**0.90**	
Green process innovation (GPCI)	3.74	0.65	0.55***	0.39***	0.55***	0.48***	**0.90**

Note: *S.D: standard deviation; Diagonal elements (in bold) are the square root of the AVE; *** $p < 0.001$.*

Table 2 shows the values of the square root of the AVE were all greater than the inter-construct correlations suggesting good discriminant validity. Overall, the above results show strong evidence for both the reliability of the constructs, and the discriminant validity of scales.

Table 3.
The fit indices of the CFA model.

Fit index	**Scores**	**Proposal threshold values**
Absolute fit measures		
CMIN/df (Chi-square/df)	1.201	$\leq 2^a$; $\leq 5^b$
GFI (goodness of fit index)	0.930	$\geq 0.90^a$; $\geq 0.80^b$
RMSEA (root mean square error of approximation)	0.026	$\leq 0.08^a$; $\leq 0.10^b$
Incremental fit measures		
NFI (incremental fit measures including normed fit index)	0.962	$\geq 0.90^a$;
AGFI (adjusted goodness of fit index)	0.912	$\geq 0.90^a$; $\geq 0.80^b$
CFI (comparative fit index)	0.993	$\geq 0.90^a$;

Note: *a: Good fit; b: Acceptable fit.*

Regarding the satisfactory of measurement model, we estimated the fit of measurement model based on examining: (1) absolute fit values (such as GFI; CMIN/df, and RMSEA); and (2) incremental fit values (such as NFI, AGFI, and CFI). Table 3 shows that all fit indices of the measurement model were satisfactory. Thus, the model fit the data.

4.4. Structural Model and Research Findings

This study performs structural equation modeling (SEM) to test the hypotheses, using AMOS software version 26.0 and maximum likelihood estimation techniques to test the proposed research model. The fit of the model is satisfactory ($\chi^a(143) = 158.125$; RMSEA = 0.019; CFI = 0.997; TLI = 0.996; IFI = 0.997), suggesting that the nomological network of relations fits the data and the validity of the measurement scales.

We perform privately three models to clarify the direct and indirect effect of green HRM practices on green innovation as well as moderating role of green culture.

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4.5. Test Direct and Indirect Effects

Model 1 used to test the direct and indirect effect of GHRM practices on green innovations via green KM practices. Findings in Table 4, Table 5 and Figure 2 show that all the standardized path coefficients of direct effects are found to be significant and in line with the stated hypothesis. Specifically:

Hypothesis H1a.b relating to the relationship between GHRM practices and two aspects of green innovation, results in the Table 4 show the positive effects of GHRM practices on green product innovation (β = 0.253; p < 0.001) and green process innovation (β = 0.347; p < 0.001). Thus, Hypotheses H1a and H1b are supported.

Regarding the relationship between GHRM practices and green KM, Table 4 indicated that GHRM practices is positively associated with green KM (β = 0.604; p < 0.001). Thus, H2 is supported.

Relating to the relationship between green KM and green innovation, the findings have confirmed the positive effects of green KM practices on green product innovation (β = 0.394; p < 0.001) and green process innovation (β = 0.350; p < 0.001). Thus, hypothesis H3a and H3b are supported.

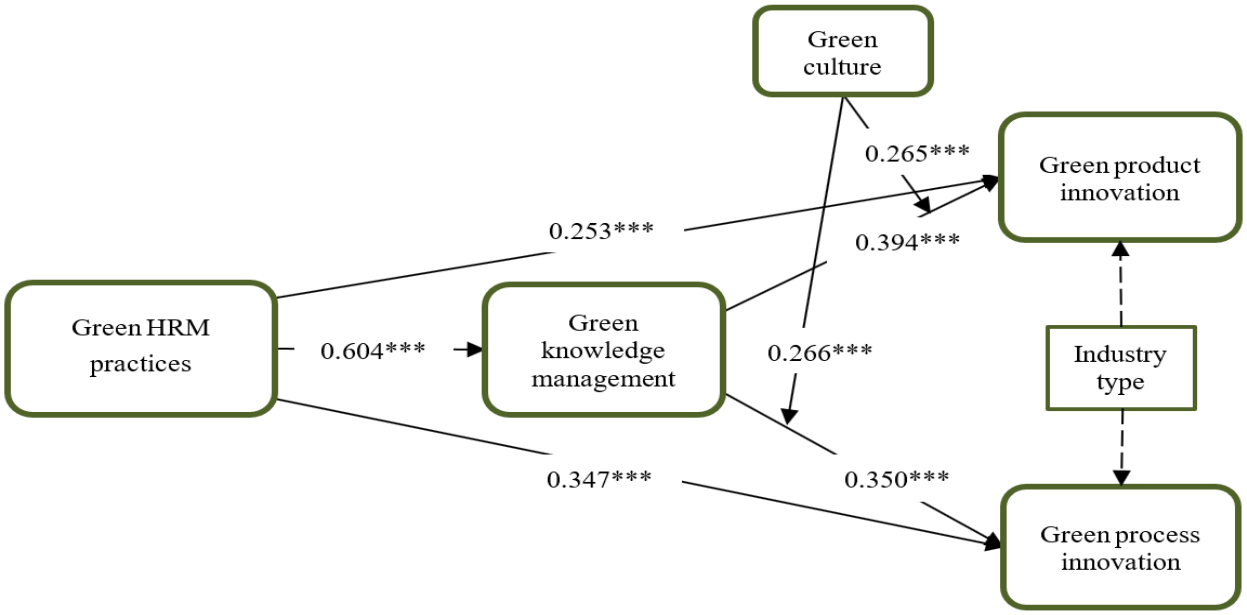

Figure 2.
Path coefficients of the structural model
Note: ***p< 0.001; ----- Non-significant paths.

Table 4.
Results of the direct relationships and moderation.

Model	Relationship	Beta	Standard error	t-value	Results
Model 1	GHRM → Green product innovation	0.253***	0.072	3.713	Supported
Model 1	GHRM → Green process innovation	0.347***	0.079	5.227	Supported
Model 1	GHRM → Green knowledge management	0.604***	0.056	9.892	Supported
Model 1	GKM → Green product innovation	0.394***	0.080	5.617	Supported
Model 1	GKM → Green process innovation	0.350***	0.087	5.188	Supported
Model 1	Industry type → Green product innovation	0.003	0.062	0.067	Not supported
Model 1	Industry type → Green process innovation	0.001	0.067	0.016	Not supported
Model 2	OGC*GKM → Green product innovation	0.265***	0.007	39.624	Supported
Model 3	OGC*GKM → Green process innovation	0.266***	0.007	38.817	Supported

Note: ***significant at the 0.001 level.

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4.6. Test Mediating Effects

To test and provide evidence on the mediating roles of green KM between GHRM practices and aspects of green innovation, the paper implements further analyses to verify the magnitude and the statistical significance of the indirect effects. For statistical inferences as the suggestion of Preacher and Hayes [66], we used the bootstrap confidence intervals method with 5,000 iterations to test the significance of indirect effects (see Table 5).

Table 5.
Confidence intervals of the indirect effects.

Model	Path	Direct effects	Indirect effects	Total effects	Bias-corrected confidence intervals	
					Lower confidence level	Upper confidence level
Model 1	GHRM→GKM→GPDI	0.253***	0.237***	0.490***	0.166	0.320
Model 1	GHRM→GKM→GPCI	0.347***	0.212***	0.559***	0.144	0.286

Note: *** $p < 0.001$.

Table 5 shows that the indirect effects of GHRM practices on green product innovation capability ($\beta = 0.237$; $p < 0.001$) and green process innovation ($\beta = 0.212$; $p < 0.001$) are statistically significant with p value < 0.001 and in the confidence intervals. Therefore, hypothesis H4a and H4b are supported. In other words, the results show the evidence on the mediating role of green KM practices and highlight that KM practices significantly mediate the GHRM practices' influences on green product and process innovations.

This study also examines the control role of industry type to account for differences among firms on green innovation. The results did not support the significant effect of these variables on firms' green innovation. In other words, industry type does not reflect the differences among firms in terms of green innovation.

4.7. Test Moderating Effects

Models 2 and 3 used to test the moderating effect of green culture in the relationship between green KM and green innovations. The results in Table 4 support H5a.b and reveal that green culture strengthens the positive effect of green KM on green product innovation ($\beta = 0.265$; $p < 0.001$) and green process innovation ($\beta = 0.266$; $p < 0.001$). In other words, this study firstly confirms the moderating role of organizational green culture in the relationship between green KM practices and two forms of green innovation namely green product and green process innovation.

5. Discussions

This study discusses the recent challenges involved in green innovation to ensure sustainable development of organizations. It contributes to the growing number of studies on the premises and mechanisms to promote green innovations through green HRM, KM practices and organizational culture. This paper contributes to enriching the theoretical understanding and managerial implications of knowledge management and innovation as follows.

5.1. Theoretical Contributions

First, previous research has found positive effects of green HRM on multiple outcomes such as employee green behaviors, green innovation, and firm's environmental performance ([5, 67]. However, there is still a need to explore how green HRM practices impact green knowledge sharing or KM practices to foster specific forms of green innovation such as green product and process innovation [18, 34]. Basing our arguments and the empirical results, this study suggests that green HRM is a strategic resource/solution that firm should leverage to shape and implement green KM which in turn to influence green product and green process innovation. In other words, green HRM is one of the most

promising practices that firms should follow to help employees have awareness of the organization's environmental beliefs and understand the values from the initial recruitment stage for sustainable development of firms.

Second, intellectual capital and knowledge resource are considered the valuable intangible assets of organizations to enhance innovation capabilities, the difference in innovation success often comes from the success of organizations' knowledge management processes [34, 68]. However, whether green KM produces positive results for specific aspects of green innovation such as green product and process innovation remains an open question and has not been satisfactorily answered [3, 41]. As a result, by examining the effect of green KM on green product and process innovation, this paper adds to understanding the role of green KM practices on green innovations and indicates that fostering green behavior of acquiring, sharing and applying knowledge is a novel and effective approach for firms to pursue green innovations.

Finally, this study integrates the concepts of green human management, green KM and green innovation into a research framework to extend the understanding of mediating role of green knowledge management. As shown by previous studies, except for the studies by Rubel, et al. [18] and Shehzad, et al. [3] that investigated the mediating role of green knowledge sharing and green KM in the relationship between key antecedent factors (such as green HRM practices and KM enablers) and green innovation, few to no studies have investigated the mediating impacts of green KM in the relationship between green HRM practices and green innovations in terms of green product and process innovation. The empirical findings verified the mediating role of green knowledge management practices in mediating the relationship between green HRM and green innovation and suggested that green HRM practices will exert significant effects on green innovation either directly or indirectly through its influence on green KM practices.

5.2. Managerial Implications

First, the empirical findings have provided the evidence supporting the positive moderator of green culture in the relationship between green KM and aspects of green innovation and revealed that green climate operates as a situational factor to enhance the influence of green KM on green product and process innovation. This study implies that CEOs and practitioners should develop and integrate green culture in their firms (for example, issuing a clear policy statement urging environmental awareness; linking environmental objectives with other goals of organization; and developing values and norms that emphasize the importance of environmental preservation) to promote the relationship between green KM practices and green innovation.

Second, green innovation enhancement is an urgent and imperative requirement for firms to create a competitive advantage, however, it is a significant challenge for small- and medium-sized enterprises in emerging economies due to lack of understanding of the right pathway and limited resources to pursuit green innovation [16, 25, 34]. Vietnam is considered as an emerging market with the economic growth rate relatively high and stable, yet Vietnamese firms are still facing with many difficulties and quite sensitive to changes in technology and innovation because most of them are small and medium size, and lack of capital, resources, and R&D capabilities to follow green innovation [69]. Accordingly, the results of this study are particularly meaningful to CEOs and managers, helping them identify the optimal and cost-effective path through green HRM practices to continuously transform green knowledge and ideas into green product and process innovation for the benefit of the organization and environmental sustainability.

5.3. Limitations and Directions for Future Research

This study has several limitations that point to future research directions. Perhaps the most significant limitation of this study is that the data are from a country, which may hinder generalization. Although Vietnamese landscape presents an interesting context as an emerging and developing market, but the regulations that are universal and take into account the specific characteristics of each field to

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enhance the protection of environmental sustainability are limited. Given this limitation, future studies should test the hypotheses of this study in other economic and cultural contexts to strengthen the research results. Secon, the cross-sectional design does not eliminate the posibility that causal correlation may emerge in the long term due to changes in the psychology and perspective of individuals over time. A longitudinal study would overcome this limitation and consolidate the results. Finally, based on the undeniable influence of green HRM and green KM practices on aspects of green innovation, this paper calls for future research to continue to explore mediating role of specific components of green KM processes and the other moderating factors to help firms shape their direction and choose appropriate solutions to enhance their green innovation capacity and attain sustainable development.

Generally, the paper significantly advances innovation theory by offering an integrative model to connect green HRM practices and green innovation via the mediating role of green KM and moderating role of green culture. This study is unique in its attempts to bring a deeper insight of a new pathway for firms to pursue green product and green process innovation.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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