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Investigating the impact of green transformational leadership on sustainable competitive performance: The mediating roles of green innovation and human resource management

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ABSTRACT

This study examines the impact of green transformational leadership (GTL) on sustainable competitive performance (SCP), with green innovation (GI) and green human resource management (GHRM) as mediating variables. Data were collected through a cross-sectional survey of management experts in the construction industry in Chongqing and analyzed using structural equation modeling (SEM). The results show that GTL has a positive and significant effect on both GI and GHRM, which in turn enhance SCP. Specifically, GTL positively influences GI (nonstandardized coefficient = 0.626, standardized coefficient = 0.456, $p < 0.001$) and GHRM (nonstandardized coefficient = 0.709, standardized coefficient = 0.482, $p < 0.001$). In addition, both GI (nonstandardized coefficient = 0.409, standardized coefficient = 0.424, $p < 0.001$) and GHRM (nonstandardized coefficient = 0.479, standardized coefficient = 0.532, $p < 0.001$) significantly improve SCP. These findings contribute to the literature on green management by providing empirical evidence that GTL enhances sustainable competitive performance through the combined mediating effects of green innovation and green human resource management. The study highlights the importance of integrating leadership, innovation, and human resource practices to achieve sustainability objectives. Practically, organizations should promote green transformational leadership to encourage innovation and align human resource policies with sustainability goals. Future studies are encouraged to investigate additional mediating mechanisms and contextual factors to further clarify how GTL influences competitive performance.

1. Introduction

Sustainability has emerged as a cornerstone of the 21st-century business landscape, moving beyond mere regulatory compliance to become a strategic differentiator that provides organizations with a competitive advantage. The present study highlights the significance of Green Transformational Leadership (GTL) in Chongqing, China's construction business, which has come under increasing scrutiny to align its boom with sustainable development. GTL includes environmental concerns in leadership doctrines, allowing firms to achieve an environmentally friendly position. However, studies on the precise methods by which leaders with green transformational leadership ability promote sustainable competitive performance (SCP), particularly in contexts such as Chongqing, where rapid urban growth presents environmental challenges, remain lacking. By concentrating on green innovation (GI) and green human resource management (GHRM) as mediators, the present study explores how these dynamics play out in an industry critical to a region's economic well-being while also providing insights into industry advances and environmental well-being.

Numerous studies in the field of green management have investigated the interplay between GTL, GHRM, and GI in influencing SCP. Singh et al. (2020) discovered that GHRM practices play a mediating role in the connection between GTL and GI, ultimately impacting the environmental performance of SMEs. This finding highlights the

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interconnectedness of these concepts. Sun et al. (2022) reported that environmental values play a mediating role in the connection between GTL and environmental performance. The authors contended that they were building upon Zhao and Huang's (2022) research on perceived organizational support in Chinese manufacturing organizations. However, they focused on different levels or stages within an organization. They emphasized that perceived organizational support could be more crucial than any other factor when considering aspects related to green management strategies, such as adoption rates among employees. While previous studies have explored the variables related to our research issue, the literature lacks a thorough understanding of the collective and linked effects of GTL on SCP, namely, through the pathways of GI and GHRM.

This study intends to address the gap in understanding the direct interactions relating to GTL, GI, GHRM summation, and SCP from the perspective of GTL, GI, GHRM, and SCP. The uniqueness of this study derives from the practical synthesis and unification of various research domains to formulate a conceptual model demonstrating the spatial and functional propagation of green leadership practices within the boundaries of an organization to achieve a sustainable competitive landscape.

This study addresses the question, 'To what extent does green transformational leadership impact competitive sustainable performance in the presence of green innovation and green human resource management as mediators?' From this question, it was clear that a quantitative approach was required to disentangle the complex interactions of the variables and to identify the mediating roles played by GI and GHRM.

This study contributes to the field of green management and leadership in two key ways. First, it provides substantial validation of the mediators' roles of GI and GHRM in the relationship between GTL and SCP. Second, it elucidates the green organizational theory by demonstrating that GTL, within a defined action and process framework, can achieve both sustainability and competitive advantage.

2. Literature review

Sustainable competitive performance refers to an organization's ability to maintain and enhance its market position by integrating sustainable practices that not only meet environmental and social responsibilities but also drive economic performance (Bari et al., 2022). This concept is critical for organizations seeking to achieve long-term success while adhering to sustainability principles. Begum et al. (2022a) explored the interplay between green transformational leadership, creative process engagement, and green innovation within the manufacturing sector and demonstrated that organizations that effectively integrate these elements can achieve superior sustainable competitive performance. Sustainable competitive performance is realized through a holistic approach that combines leadership, innovation, and human resource management, allowing organizations to create value, reduce costs, and differentiate themselves in the market (Singh et al., 2020). This research underscores that sustainable competitive performance is achieved through a holistic approach that combines leadership, innovation, and human resource management, enabling organizations to create value, reduce costs, and differentiate themselves in the market while harmonizing environmental stewardship with competitive advantage.

Green transformational leadership has been considered pivotal for the attainment of organizational sustainability and the development of environmental entrepreneurial culture within organizations (Srivastava et al., 2024; Al-Swidi et al., 2021). Singh et al. (2020) explained that green transformational leadership is critical for supporting green innovations through the application of green human resource management practices. From the arguments of Begum et al. (2022b) and Mi et al. (2019), green transformational leadership is a type of leadership that encourages and propels action toward an environmental cause within an organization and fosters the culture of innovation. This study underscores the influence that leadership has on the practices and behavior of organizations toward their employees concerning sustainability.

Sun et al. (2022), on the other hand, have shown that green transformational leadership facilitates an increase in environmental performance by promoting green innovation. They identified green human resource management and green innovation as mediating this relationship, underscoring the need for the integration of green practices into human resource management. This involves the allocation of human resources to environmental development, the fulfillment of which is an integration of the leadership and the employees' organizational concern (Sun et al., 2022). It is then evident that the application of green human resource management practices enables organizations to realize their sustainability objectives.

Green innovation, which includes both developing environmentally friendly products and improving processes, continues to hold importance for firms wanting to achieve a sustainable competitive advantage. Liu et al. (2023) studied the effect of green human resource management practices on the development of green innovation and how it further supports sustainable competitive performance. Their results suggest that companies with strong green transformational leaders are more willing to pursue systemic green innovations and, thus, attain a sustainable competitive advantage. This research highlights the long-term importance of integrating green innovation into the company's policy.

The impact of the organizational context on the relationships between green transformational

leadership, green human resource management, and green innovation is considerable. Zhao and Huang (2022) studied the moderating role of perceived organizational support on the relationships between green transformational leadership, green human resource management, and green innovation in the Chinese manufacturing industry. Their findings showed that a positive organizational climate enhances the relationships among these variables, thereby increasing their collective impact on sustainable competitive advantage.

The business studies in the literature review also highlight the multiplicative effects of sustainability initiatives on economic outcomes. Gu (2023) analyzed the drivers of green innovation and the economic performance of the hotel industry in China. The study identified green organizational culture, green organizational strategies, energy conservation, and environmental policies as major factors facilitating the adoption of green innovation. The research results showed that the economic performance of the hotels was significantly positively impacted by green innovation (Gu, 2023). This study demonstrates that the environmental benefits of sustainable business practices are coupled with practical economic benefits.

Numerous fields, such as hospitality management studies, have researched the effects of sustainable practices on employee behavior and organizational effectiveness. Farrukh et al. (2022) studied green transformational leadership and the promotion of pro-environmental behaviors through green human resource management within the industry in Pakistan. They emphasized the role of green transformational leadership in predicting employee pro-environmental behaviors, where green human resource management acted as the predicting factor. The study also confirmed the moderating role of environmental knowledge in strengthening the relationship between green human resource management and pro-environmental behaviors.

The included literature shows the complex interdependence of CSR and environmental performance. Bhat et al. (2024) studied the role of green strategy, innovation, and leadership as mediators of corporate social responsibility and environmental performance in Indian industrial companies. The influence of Corporate Social Responsibility (CSR) on environmental performance is strong and is mediated by green innovation, green capacity, environmental strategy, and green transformational leadership (Bhat et al., 2024).

Azam et al. (2023) studied the impact of total quality management and corporate social responsibility (CSR) on evaluating green innovation in small and medium-sized enterprises (SMEs) and its impact on organizational performance. The research indicated that total quality management has a positive relationship with green product innovation and green process innovation, both of which are critical aspects of green innovation. The results suggested that corporate social responsibility partially mediates the relationship between total quality management and green innovation (Azam et al., 2023). This research emphasizes the importance of integrating quality management and CSR strategies to enhance green innovation.

The review highlights the importance of green transformational leadership in encouraging green product and process innovation through the systems of creative participation in the manufacturing industry. Begum et al. (2022a) studied the impact of green transformational leadership on the adoption of green product and process innovation and the teachers of facilitating creative processes. The findings support the importance of green transformational leadership and creative process involvement in the promotion of green processes and product development.

3. Conceptual framework and hypothesis development

The conceptual framework of this study, as depicted in Fig. 1, draws from the literature on GTL, GHRM, GI, and SCP. This framework establishes GTL as a critical driver of GI and GHRM within organizations, suggesting that leaders who are committed to sustainable practices are instrumental in cultivating both innovative green processes and a workforce aligned with green objectives. Empirical support from Singh et al. (2020) illustrated the ability of GTL to direct organizational resources towards environmentally friendly innovation. Furthermore, Sun et al. (2022) validated the transformative impact of GTL on GHRM practices, which are fundamental in recruiting, developing, and retaining individuals who manifest the organization's commitment to sustainability.

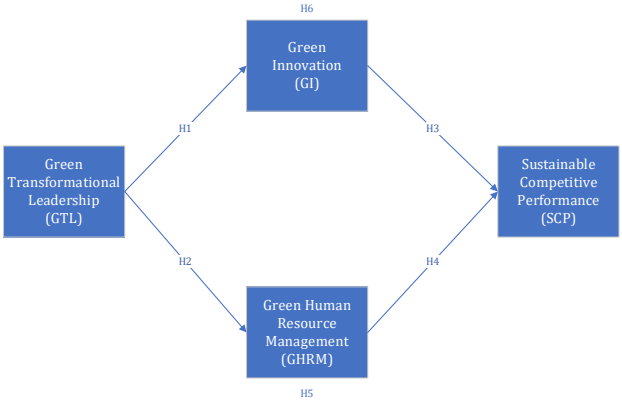

Fig. 1: Conceptual framework

At the core of this framework is the vital role of GI in achieving SCP, a premise supported by Liu et al. (2023), who provided evidence that eco-innovations are key to enhancing a firm's competitive edge. Concurrently, GHRM practices are posited not only as tools for fostering employee engagement with sustainability goals but also as catalysts for improved organizational performance, echoing the insights of Begum et al. (2022b), who indicated that GHRM is integral to inculcating a sustainable ethos into the organizational fabric and, by extension, its

competitive outcomes. The framework delineates the mediating roles of GHRM and GI in the path from GTL to the SCP. It posits that GHRM acts as a conduit through which GTL influences SCP, a connection that resonates with Zhao and Huang's (2022) findings on how organizational support systems enhance the impact of GTL on sustainable outcomes. Additionally, the framework anticipates that GI mediates the relationship between GTL and SCP, indicating that GTL, through fostering GI, contributes to improved SCP.

The research hypotheses, derived from this framework and corroborated by the literature, are articulated mainly as follows:

H1: GTL has a positive effect on the GI within organizations.
H2: GTL has a positive effect on GHRM.
H3: GI positively affects SCP.
H4: GHRM positively affects SCP.
H5: GHRM mediates the relationship between GTL and SCP.
H6: GI mediates the relationship between GTL and SCP.

4. Methodology

4.1. Research design

This study utilized a quantitative research design to empirically examine the links specified in the conceptual framework. A cross-sectional survey design was selected to evaluate the influence of GTL on SCP, with GI and GHRM serving as mediators.

The cross-sectional survey was administered to managerial professionals across various sectors of Chongqing's construction industry. This approach allowed for the collection of extensive quantitative data, which provided a snapshot of current practices and conditions related to sustainability within the industry. The survey was structured to gather information on GTL, GI, and GHRM practices and their influence on SCP.

The structured survey comprised well-designed questionnaires that were distributed to participants to capture their perceptions and experiences. The survey items were meticulously developed to ensure that they accurately reflected the constructs being measured. The survey's cross-sectional design allowed researchers to collect data at a precise moment, offering insights into the current status of sustainable development practices despite China's growing urbanization.

This methodical approach facilitated a comprehensive analysis of the best practices in sustainability, specifically how GTL influences GI and GHRM and how these, in turn, impact SCP. By utilizing a quantitative approach and cross-sectional survey design, the study was able to empirically validate the proposed relationships within the conceptual framework, offering valuable insights into the mechanisms by which green leadership can enhance competitive performance in a sustainable manner.

4.2. Sample and setting

The sampling framework for this study was designed to include a stratified cross-section of professionals from the managerial cadre within Chongqing's construction industry. The rationale behind targeting this specific demographic was based on the assumption that individuals in management positions possess a comprehensive understanding of their firm's strategic orientation toward GTL, GHRM, and GI, as well as the resulting impact on SCP.

To ensure the statistical validity of the research and determine an appropriate sample size, the Krejcie and Morgan (1970) sample size determination formula was utilized. This formula establishes a relationship between the population size and the required sample size for a specified level of accuracy and confidence. The formula is as follows:

$$s = \frac{X^2 \times N \times P \times (1-P)}{d^2 \times (N-1) + X^2 \times P \times (1-P)}$$

where, s denotes the requisite sample size; X^2 represents the chi-square statistic for 1 degree of freedom at the specified confidence level (3.841 for a 95% confidence level); N represents the population size; P denotes the population percentage (assumed to be 0.50 for optimal variability); d signifies the degree of precision represented as a proportion (0.05 for a 5% margin of error).

While precise data on the total number of managerial professionals in Chongqing's construction industry is not publicly available, this study conservatively estimated the population size at approximately 1,000. This estimate was derived from publicly available statistics showing that Chongqing had over 5,000 registered construction enterprises, with an estimated average of 3-5 managerial professionals per mid- to large-sized firm eligible for this study. This conservative estimate aligns with the industry's scale and ensures adequate sample representation. Importantly, as noted by Krejcie and Morgan (1970), for populations exceeding 1,000, the required sample size stabilizes and changes minimally, further supporting the robustness of our sample size determination.

To determine an appropriate sample size, we used Krejcie and Morgan's (1970) formula, ensuring statistical robustness. Notably, this quantification aligns with the Central Limit Theorem (Kwak and Kim, 2017), indicating that even if the actual number of managers exceeds 1,000, the determined sample size would remain sufficiently representative.

The calculation is as follows:

$$s = \frac{3.841 \times 1{,}000 \times 0.50 \times (1 - 0.50)}{0.05^2 \times (1{,}000 - 1) + 3.841 \times 0.50 \times (1 - 0.50)} \approx 278$$

Therefore, a sample size of 278 managerial professionals would be needed to ensure a 95% confidence level and a 5% margin of error.

The survey was specifically designed to gather responses from individuals holding positions such as project managers, HR officers, and other relevant managerial roles responsible for the implementation of strategic initiatives. To ensure that participants had sufficient knowledge and experience to provide informed insights, the inclusion criteria required a minimum of one year of tenure in their current role. This criterion was established to guarantee that respondents had a comprehensive understanding of their organizations' operational and strategic undertakings (Farrukh et al., 2022).

The methodological approach aimed not only to capture a snapshot of current sustainability practices within the industry but also to gather experiential insights from individuals directly involved in the planning and execution of these initiatives. This study aims to acquire a comprehensive dataset by focusing on a specific group of experts, hence enhancing the understanding of variable interactions within the construction industry (Begum et al., 2022b).

4.3. Data collection

The data collection process for this study was carefully designed and implemented to guarantee the reliability and validity of the information gathered from managerial professionals in Chongqing's construction sector. The principal instrument for data gathering was an online survey conducted using the Wenjuanxing Platform (www.wjx.cn), a reputable online survey platform in China recognized for its capacity to handle extensive data collecting efficiently.

The initial phase of the data collection procedure involved the formulation of the survey. The questionnaire was meticulously designed to incorporate multiple-choice questions and 5-point Likert-scale items that directly corresponded with the research objectives. The inquiries were formulated to elicit comprehensive insights on the respondents' perceptions and experiences with GTL, GHRM, and GI, as well as their influence on SCP. Prior to full deployment, the survey was piloted with a select group of managerial experts to ascertain clarity, relevance, and comprehensibility. The pilot test feedback was utilized to improve the survey questions, hence increasing their efficacy.

The survey began with an introductory section that explained the purpose of the study, assured participants of the confidentiality of their responses, and provided clear instructions on how to complete the survey. This introduction aimed to build trust and encourage respondents to provide honest and thoughtful answers. Each section of the survey was dedicated to one of the major constructs of the study, with carefully phrased questions to elicit clear, actionable insights. The survey was distributed primarily through WeChat, a popular social media platform widely used by professionals in China. Invitations to participate in the survey were sent via WeChat, which included a brief overview of the study and a link to the survey hosted on Wenjuanxing. To maximize participation, follow-up reminders were sent two weeks after the initial invitation and again one week before the survey ended. These reminders served to prompt those who had not yet completed the survey and to underscore the importance of their participation.

The data collection phase lasted approximately four weeks, allowing sufficient time for participants to respond at their convenience. This extended period ensured a robust sample size and accommodated the schedules of busy professionals. Throughout this period, the Wenjuanxing platform enabled real-time monitoring of response rates and data quality. This feature allowed the research team to track progress, address any issues promptly, and ensure high data integrity.

Upon completion of the data collection phase, the responses were automatically captured and stored by the Wenjuanxing Platform, minimizing the risk of errors associated with manual data entry. Strict confidentiality measures were implemented to protect the respondents' information. The data were anonymized, and access was restricted to the research team to ensure privacy.

Finally, the collected data were exported from the Wenjuanxing platform for analysis. Preliminary checks were conducted to ensure the completeness and accuracy of the data before proceeding with the statistical analysis. This methodical approach to data collection provided a solid foundation for the study, enabling the researchers to gather high-quality data that would yield reliable and valid results.

4.4. Variable measurement

As illustrated in Table 1, Robertson and Barling (2013) measured GTL as the extent to which leaders incorporated environmental sustainability into their organizational vision and motivated people to practice eco-friendliness. Renwick et al. (2013) used GHRM to evaluate how HR practices such as recruitment, training, and performance reviews support environmental goals. Chen et al. (2006) analyzed the frequency and effectiveness of organizations' new eco-friendly products and processes to quantify the GI. Finally, Dangelico and Pontrandolfo's (2015) items were used to measure the environmental and economic impacts of green efforts on competitive performance.

4.5. Data analysis

This study employed structural equation modeling (SEM) to examine the possible relationships among variables. The data were obtained via the Wenjuanxing platform and analyzed using SPSSPRO (Version 1.0.11), an online statistical analysis tool (www.spsspro.com). Data purification and preparation were conducted, encompassing

completeness checks and normality assessment, thereby offering a thorough overview of the distribution of the elements. Cronbach's alpha was employed to evaluate the scale's reliability, necessitating a minimum threshold of 0.7 to confirm internal consistency. Furthermore, the validity of all items was evaluated to confirm the precision of the constructs being measured. Structural Equation Modeling (SEM) was utilized to examine both the direct and mediated effects as defined by the established correlations among the variables.

5. Results

5.1. Demographic characteristics

Table 2 shows that the demographic profile reveals several notable patterns relevant to the study context. The predominance of participants aged 26-45 years (70.7%) with bachelor's degrees or higher (74.0%) reflects the professional nature of managerial roles in Chongqing's construction sector. The distribution across management levels, from junior managers (28.8%) to executives (20.5%), ensures the representation of diverse organizational perspectives.

Most participants (37.8%) had 1–5 years of experience in their current roles, meeting the minimum inclusion criterion of one year and providing a mix of emerging and established professionals. The gender distribution (47.9% female, 52.1% male) indicates relatively balanced representation. While these demographic variables were not included as control variables in the structural model because of the focus on organizational-level constructs, the sample composition suggests adequate diversity to capture varied perspectives on green management practices across the industry.

Table 1: Variables and items

Variables	Items	References
GTL	GTL-1. Leaders consistently communicate the importance of environmental values. GTL-2. Leaders encourage staff to think about solutions that advance sustainability. GTL-3. Leaders personally follow practices they advocate for environmental care. GTL-4. Leaders recognize and reward environmental initiatives among employees. GTL-5. Leaders drive the integration of sustainability goals into corporate strategy.	Robertson and Barling (2013)
GHRM	GHRM-1. Recruitment processes prioritize environmental consciousness. GHRM-2. Training sessions regularly include topics on sustainability practices. GHRM-3. Employee evaluations consider individual contributions to environmental initiatives. GHRM-4. HR policies facilitate employee participation in green practices. GHRM-5. Rewards and recognition are aligned with achieving sustainability targets.	Renwick et al. (2013)
GI	GI-1. The company frequently launches new products that are environmentally friendly. GI-2. Research and development is focused on developing sustainable product solutions. GI-3. Significant resources are invested in improving the sustainability of processes. GI-4. Employees are encouraged to propose innovative green solutions. GI-5. The company measures the impact of its green innovations regularly.	Chen et al. (2006)
SCP	SCP-1. Environmental initiatives have directly contributed to increased market share. SCP-2. Sustainability practices have led to a significant reduction in operational costs. SCP-3. The company has gained a competitive advantage through its green policies. SCP-4. The firm's reputation has improved due to its commitment to sustainability. SCP-5. Customer satisfaction has increased due to the company's environmental responsibility.	Dangelico and Pontrandolfo (2015)

Table 2: Demographic summary

Variable	Category	Gender		Total
		Female	Male	
Age	18-25	31(51.7%)	29(48.3%)	60
	26-35	66(44.9%)	81(55.1%)	147
	36-45	60(47.6%)	66(52.4%)	126
	46-55	18(47.4%)	20(52.6%)	38
	56+	10(66.7%)	5(33.3%)	15
Education	High school	18(52.9%)	16(47.1%)	34
	Junior college	31(47.0%)	35(53.0%)	66
	Bachelor's degree	94(50.5%)	92(49.5%)	186
	Master's degree	42(42.0%)	58(58.0%)	100
Position	Junior manager	67(60.4%)	44(39.6%)	111
	Senior manager	53(47.3%)	59(52.7%)	112
	Director	37(44.0%)	47(56.0%)	84
	Executive	28(35.4%)	51(64.6%)	79
Experience	< 1 year	20(55.6%)	16(44.4%)	36
	1-5 years	71(48.6%)	75(51.4%)	146
	6-10 years	58(45.3%)	70(54.7%)	128
	11-20 years	30(48.4%)	32(51.6%)	62
	> 20 years	6(42.9%)	8(57.1%)	14
Department	Finance	34(47.9%)	37(52.1%)	71
	Human resources	35(46.7%)	40(53.3%)	75
	Marketing	21(38.2%)	34(61.8%)	55
	Operations	49(44.1%)	62(55.9%)	111
	Others	46(62.2%)	28(37.8%)	74

5.2. Reliability and validity

The consistency of the scales quantitatively was assessed using the internal consistency method through Cronbach's alpha, as shown in Table 3. Cronbach's Alpha for scales in the study was 0.94, with the standardized Cronbach's Alpha being 0.938. These figures are statistically demonstrated to exemplify high reliability. These figures were derived from 20 items from a sample of 386 participants. Table 4 illustrates the post-deletion analytical items' dynamic summary. The post-deletion summary cycle shows the Cronbach's alpha coefficient on scales higher than the scale's norm. This suggests strong scale reliability. The mean values, variances, correlations, and the post-deletion alpha coefficient also suggest the absence of a weak item. Items GTL1 and GI1 are not weak; the total score correlations are high, and their absence minimally changes the overall alpha. Overall, this stability in the measurement scales used in this study demonstrates high reliability and internal consistency.

Table 3: Internal consistency reliability analysis

Internal consistency coefficient	Standardized coefficient	Number of items	Sample size
0.94	0.938	20	386

Table 4: Item–total statistics and Cronbach's alpha if item deleted

Item	Mean if item deleted	Variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
GTL1	51.653	215.645	0.589	0.938
GTL2	51.655	215.603	0.592	0.938
GTL3	51.661	217.149	0.529	0.939
GTL4	51.697	215.874	0.586	0.938
GTL5	51.723	218.061	0.526	0.939
GI1	51.225	200.061	0.818	0.934
GI2	51.565	216.101	0.568	0.938
GI3	51.528	214.915	0.589	0.938
GI4	51.562	212.294	0.636	0.937
GI5	51.492	215.051	0.588	0.938
GHRM1	51.459	196.940	0.834	0.933
GHRM2	51.65	211.371	0.661	0.937
GHRM3	51.65	214.275	0.610	0.938
GHRM4	51.622	212.947	0.624	0.937
GHRM5	51.661	213.020	0.635	0.937
SCP1	51.358	196.126	0.874	0.932
SCP2	51.547	212.264	0.651	0.937
SCP3	51.606	212.852	0.627	0.937
SCP4	51.712	213.795	0.620	0.937
SCP5	51.585	214.015	0.613	0.938

The Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity were employed to evaluate the appropriateness of the data for factor analysis. Table 5 demonstrates that the KMO value was 0.915, signifying a high level of sampling adequacy. This result exceeds the generally advised threshold of 0.6, indicating that the data are appropriate for factor analysis.

Bartlett's test of sphericity yielded a chi-square value of around 6942.815, with 190 degrees of freedom and a p-value of 0.000, further substantiating this finding. A statistically significant result ($p < 0.01$) demonstrates that the correlation matrix is not an identity matrix, a necessary condition for factor analysis.

Table 5: Sampling adequacy and sphericity assessment

Kaiser-Meyer-Olkin measure		0.915
Bartlett's Sphericity test	Approximate chi-square	6942.815
	Degrees of freedom	190
	Significance level (P-value)	0.000***

***: Represents 1% level of significance

5.3. SEM analysis

The regression relationships between the variables and their corresponding values are presented in Table 6. The analysis shows that GTL has a strong positive effect on GI. The non-standardized coefficient is 0.626, and the standardized coefficient is 0.456, with a p-value of 0.000. This indicates that the relationship is highly significant at the 1% level. The result highlights the important role of Green Transformational Leadership in promoting Green Innovation within organizations. Previous studies have also emphasized that environmentally responsible leaders can effectively guide organizations toward innovative and sustainable initiatives.

Similarly, Green Transformational Leadership has a significant positive effect on GHRM. The non-standardized coefficient is 0.709, the standardized coefficient is 0.482, and the p-value is 0.000, indicating significance at the 1% level. This finding suggests that leaders who prioritize sustainability play an important role in developing environmentally oriented human resource practices and aligning HR policies with sustainability goals. Furthermore, both Green Human Resource

Management and Green Innovation positively influence SCP. The effect of Green Human Resource Management on Sustainable Competitive Performance shows a non-standardized coefficient of 0.479, a standardized coefficient of 0.532, and a p-value of 0.000, indicating a highly significant relationship. These results suggest that organizations implementing green HR practices and encouraging green innovation are more likely to achieve stronger and more sustainable competitive performance.

Table 6: Model regression coefficients

Path			Nonstandardized coefficients	Standardized coefficients	Standard errors	Z	P
GTL	→	GI	0.626	0.456	0.063	10.014	0.000***
GTL	→	GHRM	0.709	0.482	0.066	10.698	0.000***
GI	→	SCP	0.409	0.424	0.035	11.766	0.000***
GHRM	→	SCP	0.479	0.532	0.033	14.671	0.000***

***: Represents 1% level of significance

To assess the adequacy of the structural model, the standardized root mean square residual (SRMR) was used as an indicator of model fit. The SRMR value of 0.116 falls within the acceptable range, as values below 0.12 are considered indicative of adequate fit in structural equation modeling (Kline, 2023). This value indicates a reasonable approximation between the observed and model-implied covariance matrices. The model demonstrates strong empirical support through highly significant path coefficients (all $p < 0.001$, as shown in Table 6).

6. Discussion

The structural equation modeling results support all six hypotheses proposed in this study. Specifically, GTL significantly influences both GI (H1: $\beta = 0.456$, $p < 0.001$) and GHRM (H2: $\beta = 0.482$, $p < 0.001$). Furthermore, both GI (H3: $\beta = 0.424$, $p < 0.001$) and GHRM (H4: $\beta = 0.532$, $p < 0.001$) significantly impact SCP. The mediating roles of GHRM (H5) and GI (H6) in the relationship between GTL and SCP are thus confirmed through these significant pathways.

This study provides empirical evidence for the relationships among green transformational leadership (GTL), green innovation (GI), green human resource management (GHRM), and sustainable competitive performance (SCP). Building upon prior research on green management and sustainability approaches, the findings offer both theoretical and practical insights.

The positive correlation between GTL, GI, and GHRM indicates that leaders who advocate for environmental sustainability also foster innovation and align HR practices with green objectives. These findings align with the findings of Singh et al. (2020) and Sun et al. (2022), who highlighted the significant role of GTL in promoting environmentally friendly practices. Additionally, the significant impact of GTL on both GI and GHRM aligns with Zhao and Huang's (2022) findings, emphasizing the importance of leadership in achieving sustainable competitive performance.

Beyond statistical significance, the practical significance of the findings merits attention. The standardized coefficients reveal that GTL has moderate-to-strong effects on both GI ($\beta = 0.456$) and GHRM ($\beta = 0.482$), suggesting that approximately 21–23% of the variance in these mediators is explained by green transformational leadership. The effects of GI ($\beta = 0.424$) and GHRM ($\beta = 0.532$) on SCP are also substantial, with GHRM demonstrating a particularly strong influence. The standardized coefficient of 0.532 for the GHRM→SCP path indicates that for every one standard deviation increase in GHRM practices, the SCP increases by 0.532 standard deviations, indicating a meaningful practical impact. These effect sizes suggest that investments in developing GTL capabilities and implementing GHRM practices yield tangible returns in terms of sustainable competitive performance.

This study contributes to the theoretical understanding of green management by empirically demonstrating the interconnected roles of GTL, GI, and GHRM in enhancing SCP. It extends the literature by providing evidence of the mediating roles of GI and GHRM, offering a comprehensive framework that links leadership, innovation, and HR practices to competitive performance. This framework underscores the necessity of integrating environmental considerations into leadership and management theories.

For practitioners, the findings suggest that organizations should prioritize fostering GTL to cultivate a culture of innovation and align HR practices with sustainability goals. By doing so, organizations can achieve a competitive advantage through sustainable practices. This study provides actionable insights for managers and policymakers, highlighting the importance of leadership development programs that emphasize environmental sustainability and the integration of green practices into HR strategies.

This study, notwithstanding its contributions, has numerous drawbacks. The cross-sectional methodology constrains causal inferences, and the emphasis on a singular industry and geographic area may reduce the generalizability of the results. Moreover, the dependence on self-reported data may add bias, since respondents may exaggerate their involvement in environmentally friendly actions.

Future research should utilize longitudinal designs to investigate the causal links among GTL, GI, GHRM, and SCP. Broadening the research to various

industries and geographical situations might improve the generalizability of the results. Furthermore, examining other mediating variables, such as organizational culture or employee engagement, may yield a more profound comprehension of the mechanisms by which GTL affects SCP. Examining the influence of external factors, like legal frameworks and market conditions, may provide significant insights into the overarching context of green management techniques.

7. Conclusion

The findings of this study illustrate that green transformational leadership (GTL) significantly influences both green innovation (GI) and green human resource management (GHRM), which subsequently enhances sustainable competitive performance (SCP). This research underscores the pivotal role of green leadership in cultivating a culture of innovation and aligning human resource practices with sustainability goals, thereby bolstering an organization's competitive edge. The results reveal that GTL not only directly impacts GI and GHRM but also indirectly promotes SCP through these mediating factors, highlighting the intricate interdependencies among leadership, innovation, and HR practices. This integrated approach offers valuable insights for organizations aiming to achieve sustainable and competitive performance, emphasizing the importance of adopting green leadership strategies that foster innovation and sustainable human resource management.

Compliance with ethical standards

Ethical considerations

Informed consent was obtained from all participants prior to survey completion. Respondents were assured of confidentiality and anonymity, and participation was voluntary. No personally identifiable information was collected.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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