The Impact of Green Transformational Leadership on Employees' Responsible Green Innovation

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Abstract: The neglect of responsibility issues in the process of green innovation can potentially undermine the legitimacy and acceptability of green innovation, thereby affecting its implementation and promotion. Therefore, scholars have called for more attention to be paid to the topic of responsible green innovation. Based on the theories of organizational identification and organizational learning, this study explores the mechanisms through which green transformational leadership influences responsible green innovation. Empirical results indicate that:(1)Green transformational leadership significantly promotes employee responsible green innovation;(2)Green transformational leadership enhances employees' exploratory/exploitative green learning levels by strengthening their green organizational identification;(3) Green organizational identification and exploratory/exploitative green learning play a significant chain-mediated role between green transformational leadership and employee responsible green innovation.We unveil how green transformational leadership influences employee responsible green innovation and provide recommendations for enhancing employee responsible green innovation.

Keywords: green transformational leadership; responsible green innovation; green organizational identification; organizational green learning.

1. Introduction

Green innovation, aimed at reducing environmental impact and improving resource efficiency [1], is of significant importance in addressing global climate change and promoting sustainable development. The United Nations Industrial Development Organization recently released its 2022 Industrial Development Report, which highlights that in the face of global resource and environmental pressures, an increasing number of countries have implemented strategic policies related to green innovation development, making support for green innovation and green transformation a strategic priority. However, green innovation can also bring about potential negative effects. For instance, technological risks, social injustices, and ethical conflicts may undermine the legitimacy and acceptability of green innovation, thereby impacting its implementation and promotion. Tesla, a globally renowned electric vehicle and clean energy company, for example, is known for its innovative battery technology and autonomous driving systems. However, Tesla's green innovation may also give rise to certain issues, such as environmental pollution and social conflicts caused by the extraction and disposal of battery materials, as well as accidents related to autonomous driving functionality. Therefore, green innovation needs to consider not only technological and economic factors but also responsibility factors, such as the principles and standards to be followed in the green innovation process, as well as how to balance the rights and obligations of different stakeholders. Consequently, scholars have called for more attention to be paid to the topic of responsible green innovation [2].

Responsible green innovation is an inclusive and participatory process wherein innovation actors and stakeholders collectively engage in the innovation process, fostering high levels of transparency and participation in research and development aimed at pollution prevention [3]. Currently, the academic understanding of the influencing factors and motivating mechanisms of responsible green innovation remains limited. Particularly, there is insufficient attention given to how to stimulate individual responsible green innovation, with only a few scholars, such as Espaillat et al., [3], conducting empirical research on the topic at the organizational level [3]. This knowledge gap hampers the practical implementation of organizational responsible green innovation because individuals ultimately serve as the actual practitioners of innovation and organizational-level responsible green innovation can only be truly realized when embodied by employees. Therefore, exploring the motivating mechanisms of employee responsible green innovation holds significant theoretical and practical implications.

Leaders often hold a unique position within organizations, controlling high-quality resources that employees require [4], thereby exerting significant influence on employee innovation. As the global ecological environment continues to deteriorate, stakeholders are calling for companies to assume environmental responsibility [5]. Companies are also increasingly aware that taking on environmental responsibility can not only improve environmental and financial performance but also have positive effects on

employees [6]. As a result, a new leadership style focused on environmental responsibility—green transformational leadership—has gained attention. Previous research has revealed the positive influence of green transformational leadership on employee green behavior and green creativity [6,7]. However, there is a lack of sufficient exploration on how green transformational leadership affects employee responsible green innovation. Green transformational leadership leads by example in taking environmental responsibility, setting an environmental protection model for subordinates, and inspiring their enthusiasm and sense of responsibility toward environmental conservation. It provides resources to develop subordinates' environmental skills, encourages them to proactively explore and try new ways of thinking and solving environmental problems [7], and promotes their display of more responsible green innovation. Therefore, the primary focus of this study is to explore the relationship between green transformational leadership and employee responsible green innovation.

According to the organizational identification theory, organizational identification is a cognitive linkage between individuals and the organization, which is collectively constructed by organizational members and influenced by them [8]. As leaders hold the power to allocate resources within the organization, they have a stronger influence on the organizational identification of other members [8]. Green transformational leadership can make employees aware of the importance of environmental protection, and their perception of meaningful work can enhance their organizational identification. Research also indicates that green transformational leadership enhances employees' green organizational identification [9]. Additionally, identification motivation is an important source of value-driven innovation. When individuals recognize the importance of innovation for organizational and personal career development, they are more willing to make efforts to promote innovation [10]. Responsible green innovation is an activity that requires high intelligence and cognitive input, conducted under multiple constraints such as responsibility, environment, and economy, making it more challenging than general innovation. Without the recognition of responsibility concepts and environmental values, the strong driving force for employees to engage in responsible green innovation cannot be stimulated. Therefore, green organizational identification is particularly important for the successful implementation of responsible green innovation.

On the other hand, according to organizational learning theory, organizational learning is the process by which employees acquire and apply new knowledge, skills, and enhance their capabilities [11]. Organizational learning plays a crucial role in helping businesses identify and respond to new opportunities, develop new products and services, and adapt to constantly changing customer needs and market environments. Furthermore, organizational learning also contributes to fostering a culture of innovation and collaboration within the company [12]. By encouraging employees to share knowledge and ideas, organizations can create a more dynamic and innovative work environment, thereby motivating employees to engage in continuous innovation and strive for improved organizational performance. With the growing attention to environmental protection topics from stakeholders [5], companies have recognized the business opportunities that come with assuming environmental responsibilities [6], thus initiating the promotion of organizational green learning. Chang and Chen [13] found that organizational green learning contributes to the enhancement of green innovation capability. Unlike green innovation, which primarily focuses on environmental protection and sustainability in product and service innovation [1], responsible green innovation not only addresses environmental and sustainability issues during the innovation process but also emphasizes the responsibility aspects of green innovation. Responsible green innovation is an effective measure for companies to dealing with environmental calls from various stakeholders. Therefore, it is necessary to explore the role of organizational green learning in the process of responsible green innovation.

This study builds upon previous research achievements in the areas of green innovation and responsible innovation, integrating the issue of responsibility into the study of green innovation. Drawing upon organizational identification theory and organizational learning theory, we investigate the influence of green transformational leadership on employee responsible green innovation, as well as the mediating roles of green organizational identification and organizational green learning. By doing so, we aim to unveil the "black box" of how green transformational leadership influences employee responsible green innovation and provide recommendations for enhancing employee responsible green innovation.

2. Theory and Hypotheses

2.1 The Influence of Green Transformational Leadership on Employee Responsible green innovation

Given the escalating global environmental and resource issues, traditional economic development models are no longer adequate to meet the needs of humanity. People are increasingly recognizing the interdependence of the economy, environment, and society, and the need to achieve long-term economic growth and social progress through sustainable development. Responsible green innovation, as an extension of green innovation, incorporates the concept of responsible innovation, which highlights not only the economic and environmental benefits but also the social responsibilities, ethical obligations, and the impact and responsibilities of innovation on stakeholders [3]. Compared with green innovation, responsible green innovation places greater emphasis on comprehensive consideration of environmental, social, and ethical issues within innovation. Responsible green innovation also emphasizes collaboration and win-win relationships between companies and stakeholders, including employees, customers, suppliers, and communities.

Therefore, responsible green innovation is a more comprehensive and holistic approach to green innovation that can better promote sustainable development for businesses. However, research specifically on responsible green innovation is still in its early stages. Firstly, current research on responsible green innovation is mainly built upon the theoretical foundations of responsible innovation, and the study of responsible innovation itself is primarily in the stage of theoretical framework construction, research paradigm integration, and macro policy analysis. Secondly, there is a lack of research on responsible green innovation at the employee level, with only a few scholars exploring responsible green innovation topics from the perspective of the company. For example, Espaillat et al. [3] studied the role of corporate social responsibility in promoting responsible green innovation. We will focus on the mechanisms that stimulate employee responsible green innovation.

Leadership style is an important predictor of employee behavior, and previous research has explored the influence of green transformational leadership on employee green behavior and green creativity [7]. The concept of green transformational leadership inherently encompasses the goal of corporate environmental responsibility [6]. This objective not only necessitates environmentally friendly production and operations but also calls for green transformational leaders to carefully balance the interests of various stakeholders and uphold principles of openness, transparency, and fairness when contemplating green production and operations. Therefore, it is crucial to explore the impact of green transformative leadership on employee-driven responsible green innovation. Green transformational leadership is a leadership style that "motivates subordinates to achieve green environmental goals and surpass preset expectations of environmental performance" [7], including four dimensions: environmental idealized influence, environmental inspirational motivation, environmental intellectual stimulation, and environmental individualized consideration [6]. Green transformational leadership sets an environmental example for employees through personal charisma (environmental idealized influence) [6], making employees aware of the importance of environmental protection and inspiring their environmental responsibility. It encourages employees to go beyond personal short-term interests and strive for organizational environmental goals (environmental inspirational motivation) [6], stimulating employees' environmental enthusiasm. It helps employees develop environmental skills (environmental individualized consideration), enhancing employees' green innovation capabilities. It encourages employees to challenge old ways of thinking and use new methods to solve environmental issues (environmental intellectual stimulation) [6], promoting green innovation among subordinates. In summary, we hypothesize that green transformational leadership stimulates employees' environmental responsibility and environmental enthusiasm through environmental idealized influence and environmental inspirational motivation, enhances employees' green innovation capabilities and behaviors through environmental individualized consideration and environmental intellectual stimulation, and encourages employees to demonstrate more responsible green innovation behaviors. Therefore, we propose the following hypothesis:

H1: Green transformational leadership positively influences Responsible green innovation.

2.2 The Mediating Role of Green Organizational Identification in the Relationship between Green Transformational Leadership and Responsible green innovation

Organizational identification is the most central, enduring, and distinctive belief about an organization held by its leaders and members. Establishing a unified identification that organization members can understand and adhere to is one of the main goals of leadership [14]. As leaders have a significant influence on employees' perceptions, emotions, and thoughts about the organization [15], organizational identification is primarily formed by top leaders' interpretations and beliefs, which guide and drive organizational and employee behavior. Green transformational leadership can inspire an environmental vision and incorporate it into organizational identification, leading to the formation of green organizational identification among members. Firstly, green transformational leadership possesses unique personal charm and environmental influence, which helps inspire employees' positive attitudes toward environmental protection and sustainable development. This, in turn, leads to the formation of cognitive recognition of organizational environmental protection and management, known as green organizational identification. Secondly, green transformational leadership inspires employees' environmental enthusiasm and responsibility through motivation for environmental protection, allowing employees to perceive greater self-worth and significance in environmental causes. This, in turn, stimulates employees' green organizational identification [8]. Thirdly, green transformational leadership demonstrates environmental care for employees, creating a sense of warmth that fosters trust and recognition of the leader's environmental advocacy. This further promotes employees' green organizational identification. Existing research has also confirmed that green transformational leadership is an important antecedent to employees' development of green organizational identification [8]. Based on this, we predict that green transformational leadership can promote employees' green organizational identification.

Responsible green innovation includes four characteristics: inclusiveness, which involves involving innovation stakeholders in the green innovation process; predictability, which considers the ethical and social aspects of new green technologies in the early stages of innovation; introspection, which refers to the self-reflection of the innovation entity; and

responsiveness, which involves matching the innovation evolutionary process with social value dynamics. Organizational identification further influences employee behavior through its impact on employees' cognition and emotions. Therefore, we suggest that green organizational identification can influence responsible green innovation in terms of inclusiveness, predictability, introspection, and responsiveness. Regarding predictability, employees with high green organizational identification can develop stable environmental awareness and make environmental commitments. Environmental commitments guide members to integrate internal knowledge and consider the acceptability of new products/services from ethical and social perspectives in the early stages of innovation. This promotes responsible green innovation by reducing environmental costs, improving environmental efficiency, and reducing environmental pollution. From the perspective of inclusiveness, during the innovation process, organizational members can be motivated by a unified green organizational identification to discover meaningful connections between new technologies and stakeholders' environmental needs, thereby finding creative environmental approaches that enhance innovation [13]. In terms of introspection, guided by green organizational identification, the innovation entity repeatedly examines the assumptions, objectives, execution processes, and outcomes of innovation, considering whether they meet the requirements of green sustainable development to enhance the sustainability of green innovation. From the perspective of responsiveness, green organizational identification can enhance employees' level of awareness regarding Responsible green innovation, leading them to better understand and pay attention to environmental and social issues that may arise during the innovation process. This promotes their adaptive learning process, thereby enhancing employees' innovation knowledge and control, ultimately improving the dynamic alignment between the innovation process and social values. Therefore, we hypothesize a positive impact of green organizational identification on Responsible green innovation. Based on these discussions, the following hypotheses are proposed:

H2: Green organizational identification plays a positive mediating role in the relationship between green transformational leadership and responsible green innovation.

2.3 The Chain Mediating Role of Green Organizational Identification and Organizational Green Learning in the Relationship between Green Transformational Leadership and Responsible green innovation

Organizational learning is a corrective process through which organizational members reshape organizational actions. It is the process by which organizations develop corresponding capabilities and knowledge based on past experiences and apply them to future actions, to enhance organizational competitiveness and performance [11]. Organizational learning can be classified into exploitative learning and exploratory learning. Exploitative learning involves the extension and refinement of existing knowledge, experience, and technologies, while exploratory learning entails the exploration and development of new knowledge and technologies. Organizational learning emphasizes collective learning among organizational members based on organizational beliefs, rules, and procedures. However, organizational learning is still grounded in individual learning and involves social interactions among members within the organization to enhance knowledge capabilities and reshape organizational actions. Organizational green learning can be regarded as an organizational learning process that aims to help organizational members acquire green knowledge, skills, and values to better address environmental challenges and achieve sustainable development. Green transformational leadership provides guidance and support for organizational green learning by socializing members through their own green values and behavioral role modeling, inspiring members to go beyond conventional thinking and approaches in addressing environmental issues and helping them enhance green knowledge and skills. Therefore, we hypothesize that green transformational leadership facilitates organizational green learning among employees.

Based on the above analysis, this study posits that green organizational identification and organizational green learning play a chain mediating role in the relationship between green transformational leadership and Responsible green innovation. Firstly, green transformational leadership employs environmental influence to socialize the goals of environmental protection and green development into employees' attitudes and values, leading to the formation of green organizational identification [8]. This process stimulates employees' environmental enthusiasm, sense of responsibility, and the establishment of a green shared vision [16]. When employees have a deeper understanding of environmental issues and possess a stronger sense of environmental responsibility and agency, they are more willing to engage in responsible green innovation. Through continuous organizational green learning, they explore and implement environmental solutions to drive the organization's sustainable development. Secondly, green transformational leadership, with its acute insight and effective decision-making ability, timely identifies environmental changes and the environmental needs of stakeholders, adjusting organizational strategies, objectives, and actions accordingly. It also encourages employees to think creatively and address environmental issues in novel ways to respond to these changes and needs. By promoting organizational green training, knowledge sharing, and learning from green projects, organizational green learning enhances the environmental capabilities and environmental literacy of organizational members, facilitating the realization of Responsible green innovation. Furthermore, organizational green learning is a process of reflection and correction [11]. It prompts organizational members to assess and reflect upon the

environmental effectiveness and social impact of their actions, continuously optimizing the practice and outcomes of responsible green innovation, thereby achieving the environmental goals set by green

H3a: Green organizational identification and exploitative green organizational learning play a chain mediating role in the relationship between green transformational leadership and responsible green innovation.

H3b: Green organizational identification and exploratory organizational green learning play a chain

transformational leadership—beyond expected environmental performance. Therefore, this study proposes the following hypotheses:

mediating role in the relationship between green transformational leadership and responsible green innovation.

In summary, the theoretical model of this study is presented as follows in Figure 1:
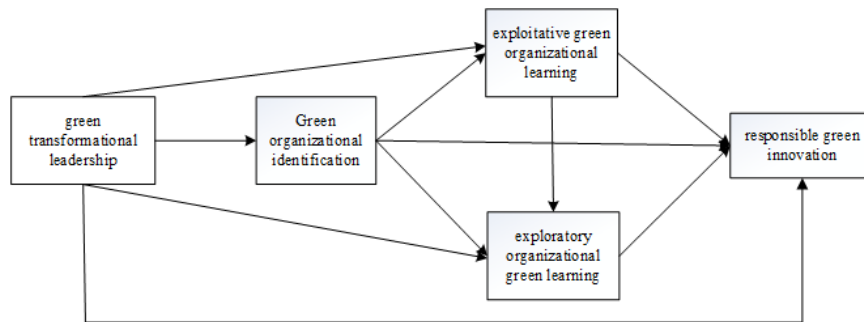

Figure 1. Theory model

3. Method

3.1 Sample and Procedure

A total of 382 chinese employees were randomly recruited through a professional data collection platform (credamo). After eliminating 12 individuals who did not provide serious responses and did not pass the system screening, a total of 370 participants took part in the formal survey. We administered the questionnaires in two stages, with a one-month interval between each stage. Time 1 measured the green transformational leadership, the organizational green identity of participating employees, as well as demographic information such as gender, age, years of work experience, education level, job position, and department. Time 2 measured variables related to employees' exploitative and exploratory organizational learning and responsible green innovation. Participants received a reward of 2 yuan for each completed questionnaire, and those who completed both time points received a total reward of 4 yuan per participant. In the end, a total of 290 valid questionnaires were successfully matched, resulting in a questionnaire valid response rate of 78.38%. The final sample included 290 employees from various companies and industries. Participants were 49.7% female and most were between 20 and 40 years old (89%), most had a bachelor's degree (76%) and 197 participants had an income between 110,000 and 300,000 yuan.

3.2 Measures

The measurement scales used in this study were adopted or adapted from mature scales published in authoritative international journals. All English scales were translated into Chinese following standard translation and back-translation procedures by experts

proficient in both Chinese and English. All variables were measured using a 7-point Likert scale.

Green Transformational Leadership. We used a 4-item simplified scale adapted from the Environmental Transformational Leadership Scale developed by Jennifer et al. (2018) [6]. A typical item includes "My leader sets a good example in environmental protection." The α reliability coefficient for green transformational leadership in this study was 0.84.

Organizational Green Identity. We used Chen et al.'s [8] 4-item Green Organizational Identity Scale. A typical item includes "I take pride in my company's environmental goals and mission." The α reliability coefficient for organizational green identity in this study was 0.74.

Organizational Green Learning. The scale for organizational green learning was developed based on Atuahene-Gima et al.'s [17] Green Organizational Learning Scale and consisted of 9 items. This scale includes 5 items for exploitative organizational green learning, with a typical item being "We search for information and learn about conventional ways to save energy and resources." The α reliability coefficient for exploitative organizational green learning in this study was 0.70. Additionally, the scale includes 4 items for exploratory organizational green learning, with a typical item being "We gather green environmental information and ideas beyond existing market and technological experiences." The α reliability coefficient for exploratory organizational green learning in this study was 0.74.

Responsible Green Innovation. We used Espaillat et al.'s [3] scale with 4 items. A typical item includes "I involve various stakeholders in the innovation process concerning environmental issues within the company." The α reliability coefficient for responsible green innovation in this study was 0.74.

4. Analysis

4.1 Descriptive Statistics

The means, standard deviations, and correlation coefficients of the main variables in this study are presented in Table 1. Green transformational leadership is significantly positively correlated with green organizational identification (r=0.662, p<0.01) and responsible green innovation (r=0.646, p<0.01). Green organizational identification is significantly positively correlated with exploitative green organizational learning (r=0.470, p<0.01), exploratory green organizational learning (r=0.580, p<0.01), and responsible green innovation (r=0.597, p<0.01). Exploitative green organizational learning (r=0.589, p<0.01) and exploratory organizational learning (r=0.646, p<0.01) are significantly positively correlated with responsible green innovation. These findings provide preliminary support for the proposed hypotheses.

Table 1. Descriptive Statistics and Correlation Analysis of the Main Variables (N=290)

Variable	Mean	SD	1	2	3	4
1Green Transformational leadership	5.68	0.95				
2Green organizational identification	5.89	0.73	0.66**			
3Exploitative green organizational learning	5.89	0.64	0.46**	0.47**		
4Exploratory green organizational learning	5.85	0.76	0.52**	0.58**	0.64**	
5Responsible green innovation	5.79	0.83	0.65**	0.60**	0.59**	0.65**

Note: ***= p<0.001; ** =p<0.01; *= p<0.05.

4.2 Measurement Model

To test the validity of our measures, we conducted confirmatory factor analysis with MPLUS8.1 to examine our proposed measurement model (i.e., green transformational leadership, organizational green identity, exploitative organizational green learning, exploratory organizational green learning, and responsible green innovation.). The results indicated that the proposed five-factor model showed good fitness (χ^2/df = 2.19, CFI = 0.908, TLI = 0.900, RMSEA = 0.064, SRMR = 0.055). The fit indices were better than the suggested values and superior to the fit indices of the other four competing models, as shown in Table 2. Overall, the structural validity of the five-factor model was good, and the comparative results with the competing models indicated good discriminant validity among the variables.

Table 2. Model fit of competition model(N=290)

model	χ^2	df	χ^2 /df	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$ (Δdf)
One factor model	616.83	189	3.26	0.82	0.79	0.088	0.066	222.34***(10)
Two-factor model	591.89	188	3.15	0.83	0.81	0.086	0.067	199.40***(9)
Three-factor model	490.48	186	2.64	0.87	0.85	0.075	0.062	97.98***(7)
Four-factor model	402.34	183	2.20	0.91	0.89	0.064	0.055	9.85*(4)
Five-factor model	392.49	179	2.19	0.91	0.90	0.064	0.055	

Note: *** = p<0.001; ** = p<0.01; * = p<0.05

4.3 Hypothesis Testing

Hypothesis testing was conducted using the Process 3.0 plugin in SPSS software through 5000 bootstrap resampling. Model 6 in the Process 3.0 plugin was used to test hypotheses H1, H2, H3a, and H3b, with green transformational leadership as the independent variable, responsible green innovation as the dependent variable, and green organizational identification, exploitative green organizational learning, and exploratory green organizational learning as the mediating variables. The results are shown in Table 3.

The results in Table 3 indicate a significant positive direct effect of green transformational leadership on responsible green innovation (β=0.281). The 95% confidence interval [0.191, 0.372] does not include zero, supporting hypothesis H1.

The bootstrap resampling results in Table 3 show that the 95% confidence interval for the mediation effect of green organizational identification between green transformational leadership and responsible green innovation is [-0.009, 0.190], which includes zero. Therefore, hypothesis H2 is not supported. Additionally, the 95% confidence interval for the mediation effect of green organizational identification between green transformational leadership and exploitative green organizational learning is [0.072, 0.266], excluding zero, indicating a significant positive mediation effect (β=0.160). Similarly, the 95% confidence interval for the mediation effect of green organizational identification between green transformational leadership and exploratory green organizational learning is [0.063, 0.271], excluding zero, demonstrating a significant positive mediation effect (β=0.152).

The 95% confidence interval for the chain mediation effects of green organizational identification and exploitative green organizational learning between green transformational leadership and responsible green innovation is [0.010, 0.085], which does not include zero, indicating a significant chain mediation effect (β=0.034) between these variables, supporting hypothesis H3a. Similarly, the 95% confidence interval for the chain mediation effects of green organizational identification and exploratory green organizational learning between green transformational leadership and responsible green

innovation is [0.012, 0.112], excluding zero, demonstrating a significant chain mediation effect

(β=0.045) between these variables. supporting hypothesis H3b.

Table 3. Mediation Analysis Results(N＝290)

	Hypothesis and Paths	Coefficient	S.E.	95% CI	
				Boot LLCI	Boot ULCI
H1	GTL->RGI	0.281	0.046	0.191	0.372
H2	GTL->GOI->RGI	0.075	0.051	-0.009	0.190
	GTL->GOI->OGS1	0.160	0.049	0.072	0.266
	GTL->GOI->OGS2	0.221	0.061	0.063	0.271
H3a	GTL->GOI->OGS1->RGI	0.034	0.018	0.010	0.085
H3b	GTL->GOI->OGS2->RGI	0.045	0.024	0.012	0.112

Note: GTL=Green Transformational leadership; GOI=Green organizational identification; OGS1=Exploitative green organizational learning; OGS2= Exploratory green organizational learning; RGI= Responsible green innovation. S.E.= standard error

5. Discussion

5.1 Conclusion

By integrating the perspectives of organizational identification theory and organizational learning theory, we constructed a chain mediation model from green transformational leadership to employee responsible green innovation, with green organizational identification and exploitative/exploratory green organizational learning as mediating variables. After analyzing survey data from 290 employees, the following conclusions were drawn: (1)Green transformational leadership significantly promotes employee responsible green innovation;(2) Green transformational leadership enhances employees' exploratory/exploitative green organizational learning by strengthening their green organizational identification;(3) Green organizational identification and exploratory/exploitative green organizational learning play significant chain mediation roles between green transformational leadership and the employee responsible green innovation.

5.2 Theoretical Contributions

Firstly, this study partly addresses the research gap in understanding the mechanisms that stimulate employee responsible green innovation. Existing studies on responsible green innovation have mainly focused on macro-level issues such as conceptualization, theoretical frameworks, and policy governance mechanisms while paying little attention to how to stimulate individual responsible green innovation. However, the foundation of responsible green innovation lies in micro-level entities such as enterprises and employees, and macro-level policies and governance mechanisms ultimately need to be implemented through enterprises and their employees to have an impact on responsible green innovation. Therefore, studying the mechanisms of micro-level responsible green innovation is of great theoretical significance.

Secondly, this study also contributes to the research field of green transformational leadership. Existing research has confirmed the influence of green transformational leadership on employee green behavior [6] and green creativity [7], but neglected the impact of green transformational leadership in terms of responsibility on employee innovative behavior. Green transformational leadership is an effective leadership

style for organizations to take environmental responsibility, and we believe that it inherently includes elements of considering stakeholders' responsibilities. Based on organizational identification theory and organizational learning theory, this study verifies the positive impact of green transformational leadership on employee responsible green innovation, enriching the relevant theoretical research on green transformational leadership.

Thirdly,this study confirmed the chain mediation effect of green organizational identification and organizational green learning between green transformative leadership and employee-driven responsible green innovation. This clarifies how green transformative leadership influences employee-driven responsible green innovation. Green transformative leadership shapes employees' green organizational identification, motivating them to strive for environmental goals and supports their organizational green learning. This enhances employees' environmental capabilities and passion, ultimately promoting responsible green innovation. The study contributes to our understanding of the factors influencing responsible green innovation.

5.3 Managerial Implications

First, it is important to strengthen the attention to green transformational leadership, cultivate leaders' environmental awareness, and enhance their awareness of environmental responsibility. Relevant departments can provide regular environmental protection training for business leaders, promote the importance of environmental protection, and make leaders realize the impact of environmental protection on the sustainable development of the company. Secondly, strengthening the promotion of environmental protection to various stakeholders, establishing a stakeholder environmental supervision mechanism, and leveraging the monitoring role of environmental policies, media, and the public can exert external pressure to foster the emergence of green transformational leadership.

Second, The mediating role of green organizational identification between green transformative leadership and responsible green innovation has not been confirmed, indicating that green organizational identification does not directly impact employee responsible green innovation. In management practices, it is important to note the conversion of the psychological advantages of

green organizational identification into actionable behaviors.Considering that green organizational identification can strengthen the positive relationship between green transformational leadership and organizational green learning, environmental protection and sustainable development should be emphasized in employee training to cultivate an organizational culture that promotes environmental protection. This will encourage employees to develop a stronger sense of green organizational identification and stimulate more organizational green learning. Through training and communication, employees should be made aware of the organization's environmental policies and goals, educated on how to take environmental actions and adopt environmentally friendly practices, and their environmental awareness and actions should be enhanced. Additionally, setting clear environmental goals for the organization and ensuring that employees understand their roles and responsibilities in achieving these goals can foster a more stable and sustainable organizational green learning.

Thirdly, in the process of advancing responsible green innovation, it is crucial for the government, businesses, and society to collectively shoulder the responsibility. This can be achieved by employing legislative measures, policies, and administrative tools to promote responsible green innovation and create a legal and market environment conducive to its development. Strengthening regulatory oversight and guidance for businesses is essential to steer them towards embracing green principles and fulfilling their corporate social responsibility. The general public plays a significant role as participants and advocates in green innovation. They should actively engage in the dissemination, promotion, and implementation of responsible green innovation. Society should support and encourage responsible green innovation through various means, such as purchasing eco-friendly products, advocating for low-carbon lifestyles, and supporting environmental organizations. At the same time, society should also condemn environmentally unfriendly corporate behavior and promote corporate environmental responsibility.

5.4 Limitations and Directions for Future Research

First, all variables in this study were self-reported by employees, which may introduce bias due to social desirability. In future research, data collection can be conducted using methods such as having employees evaluate green transformational leadership and green organizational identification, while leaders evaluate employees' organizational green learning and responsible green innovation, to enhance the external validity of the research.

Second, the study overlooked the exploration of the boundary conditions of the chain mediation mechanism between green transformational leadership and responsible green innovation. Future research can further explore the boundary conditions that facilitate responsible green innovation, thus enriching and guiding practical applications.

Third, Responsible green innovation encompasses not only individual-level responsible green innovation but also team and organizational-level responsible green innovation. Future research can integrate the concepts of responsible green innovation at the employee, team, and organizational levels to provide a more comprehensive understanding of the underlying relationships of multi-level responsible green innovation.

Finally, this study primarily focuses on the relationship between leadership style and employee attitudes and behaviors in promoting responsible green innovation. However, it overlooks internal factors such as organizational culture, organizational climate, and human resource management measures, as well as external factors including business environment, regional innovation culture, and national innovation policies, that may influence responsible green innovation. In the future, it would be beneficial to adopt a holistic approach by considering responsible green innovation as a system and employing the QCA analysis method to develop comprehensive strategies for enhancing responsible green innovation, taking into account both internal and external organizational environments, as well as the interests of relevant stakeholders.

Biographies

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