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The Use of ESG in Facilitating Eco-Innovation Via Green Innovation: Approaching the Moderated Mediation Role of Top Manager's Environmental Awareness

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Article

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Abstract

Eco-innovation drives environmental sustainability and creates new economic opportunities, yet how Environmental, Social, and Governance (ESG) performance shapes the eco-innovation process remains underexplored. Grounded in the Resource-Based View (RBV), we argue that ESG constitutes a strategic resource that fosters Green Innovation (GI), which in turn facilitates Eco-innovation (EI). Building on Upper Echelons Theory (UET), we further examine how Top Manager's Environmental Awareness (TMEA) moderates this mediating pathway. Survey data were collected from 371 participants across 29 small and medium-sized enterprises (SMEs) in China. Results indicate that ESG exerts both a direct effect on EI and an indirect effect through the partial mediating role of GI. Moreover, TMEA significantly moderates the mediated relationship from ESG to EI via GI. These findings integrate RBV and UET to elucidate the ESG–EI nexus, and provide practical implications for SMEs seeking to leverage ESG engagement and leadership environmental awareness for sustainable innovation.

. Introduction

EI has attained prominence on the global political agenda, particularly in China, where there has been a substantial growth in its implementation (Ullah et al., 2024). Additionally, the integration of ESG in development strategies has emerged as a pressing concern for global researchers in the practice of ecological innovation (Ruan et al., 2023). EI refers to the desire to reduce pollution and improve environmental quality through strategic application (Wu et al., 2024). Consequently, EI is indispensable for realizing sustainable development, as it alleviates the environmental ramifications of production cycles, boosts the adaptive capacity of ecosystems to environmental disruptions, and advocates for the accountable and optimal exploitation of natural resources (Chau et al., 2023). Additionally, EI minimizes the adverse effects of industrial operations by implementing new products and services, refining production methods, and optimizing resource management, which greatly decreases the environmental damage associated with the industry (Chien et al., 2024). These theories and perspectives underscore the future, in which ecological innovation serves as a strategic approach that transcends human creativity to effectively incorporate sustainability and ESG principles into development strategies.

EI is vital for transitioning to a circular economy, which is a fundamental aspect of sustainable development. This process helps transform waste into usable resources, thereby reducing environmental impacts in a circular system (Ghisellini, Cialani & Ulgiati, 2016)). EI promotes environmental protection by reducing natural resource consumption and controlling harmful substance emissions at each stage of the product lifecycle (Hojnik & Ruzzier, 2016). It encompasses technological advancements, as well as social and institutional innovations, which are essential for achieving sustainable development (Rennings, 2000). EI enhances a firm's market standing by drawing in customers and providing green services, thus ensuring a competitive edge (Takalo & Tooranloo, 2021). Moreover, EI supports public policies by providing comprehensive statistical indicators that facilitate ecological transitions and sustainable development (Rotondo et al., 2022). Collectively, these points underscore the significance of EI within organizations.

In light of this research context, the study proposes that utilizing ESG is crucial for encouraging employee EI. ESG includes metrics that assess a firm's dedication to sustainable and ethical operations (Huang, 2021). Through the implementation of ESG practices, businesses can recognize and address risks tied to environmental decline, social issues, and governance shortcomings that might lead to financial setbacks and reputational damage (Khan et al., 2016). Embracing ESG principles allows companies to gain a competitive edge via innovation, improved resource efficiency, and enhanced brand equity, which in turn contributes to sustained financial prosperity (Orlitzky et al., 2003). Moreover, ESG can catalyze the maturity of EI technologies and inspire enterprises to invest in sustainable technologies and practices, thus laying the foundation for new green products/services and enabling the dual-regulation policy of environmental protection and economic development (Schaltegger & Wagner, 2011). According to these theories, a workplace that emphasizes ESG is expected to motivate employees' EI. This research indicates that ESG-focused can improve employees' EI skills.

ESG is crucial for attracting investments as it demonstrates a firm's commitment to generating long-term value and handling risks, in line with the objectives of socially responsible investors (Gompers & Metrick, 2001). The significance of ESG in shaping corporate reputation cannot be overstated as it directly influences consumer perception, customer loyalty, and overall brand value in the market (Laufer, 2003). Furthermore, EI, as a positively correlated factor, can drive organizational sustainability and development, resulting in a competitive advantage in the industry. ESG elevates a firm's image while also promoting EI by incentivizing the development of products and procedures that are more sustainable and eco-friendlier (Lubin & Esty, 2010). Consequently, this study posits that investigating the degree of ESG adoption within SMEs and elucidating the causal relationship between ESG practices and employee-driven EI is of significant importance in the realm of academic research.

This research seeks to investigate the ways in which ESG factors facilitate EI, as well as to identify the variables that significantly impact the relationship between ESG and the involvement of employees in fostering eco-innovative initiatives. Specifically, this research demonstrates that employees' engagement in GI serves as a mediating factor in their efforts towards EI. GI pertains to the approach through which organizations create and roll out novel products, offerings, or procedures that boost environmental performance while concurrently producing economic value and social benefits (Horbach, 2008). Incorporating ESG principles into business strategies has been proven to encourage GI, as it matches the demand for economically feasible and environmentally sustainable operations (Schaltegger et al., 2016). Moreover, prior studies indicate that GI positively affects EI (Horbach, 2008). Therefore, ESG principles establish the foundation for sustainable business practices by emphasizing responsible governance, social equity, and environmental stewardship. These principles have spurred eco-friendly innovations in fields like renewable energy and waste reduction. Consequently, GI catalyzes the broader field of EI, resulting in advancements in sustainable technologies and processes that benefit the entire ecosystem. Consequently, ESG can exert a beneficial influence on EI by fostering GI.

Grounded in UET, which posits that top managers' cognitive bases and values shape their interpretation of strategic situations and subsequent corporate decisions (Hambrick & Mason, 1984), this research

posits that the moderating influence of TMEA can substantially amplify the effects of ESG and GI on employees' EI. The TMEA is a key factor in the successful implementation of ESG, and it also determines the initiatives taken by enterprises to promote sustainable development and the direction of their exploration in EI (Melville, 2010). This awareness has a powerful driving capability for the implementation of GI, as it directly determines the enterprise's emphasis on sustainable development strategies and the enforcement strength of environmental protection (Longo et al., 2005). Consequently, this research posits that the TMEA fosters employee engagement in the execution of GI, thereby facilitating the advancement of EI. Considering that the TMEA may serve as a moderating factor, it is essential to investigate its potential influence on the relationship between ESG or GI and employees' EI.

Drawing on the RBV, which holds that a firm's valuable, rare, inimitable, and non-substitutable resources constitute the foundation of competitive advantage (Barney, 1991), this study views ESG as such a strategic resource that drives GI and ultimately EI. Considering the previously examined research context and theoretical frameworks, it is evident that employee-driven EI has become a critical issue for contemporary SMEs in China to confront. The research objectives are as follows: First, current studies suggest that empirical research on ESG and employee EI in the Chinese academic community is relatively limited. Consequently, this study aims to explore the relationship between ESG and employees' EI, as well as the interaction mechanisms that enhance the promotion of EI among employees through ESG. Through this analysis, the research seeks to make a significant contribution to the existing literature on ESG and EI.

Second, previous research has predominantly concentrated on investigating the antecedent factors associated with EI (Pan et al., 2021; Rodríguez et al., 2021) and analyzing the variables that may have mediating and moderating influences on EI (Zhao et al., 2023; Achmad et al., 2023). This study further broadens the research scope of EI and proposes and validates a moderated mediation model.

Third, while research on ESG has been ongoing, this study clearly outlines the role of ESG in SMEs and explains its importance to these organizations. This study also elucidates how ESG influences employees' EI.

Fourth, most research views TMEA as either a dependent variable or a mediator. Nevertheless, this research designates a moderating role for it and investigates its impact on that ability. Specifically, this study regulates the mediating role of employees' GI by analyzing the interaction between ESG/GI and TMEA, thereby promoting the development of EI.

In conclusion, this study contends that there is presently insufficient in-depth research on ESG in Chinese SMEs and clarifies ESG's role in these enterprises. This study will help expand ESG research. This research presents a new model to investigate ESG and its influence on employees' EI. Furthermore, this study makes a substantial contribution to the domains of ESG and EI. It specifically examines the TMEA within Chinese SMEs and enhances the comprehension of the critical role that EI plays in these organizations by investigating its interplay with ESG and employee-driven GI. By integrating RBV and UET,

this study provides a coherent theoretical lens to understand how ESG resources are transformed into EI outcomes through GI, and how this transformation is contingent on TMEA among Chinese SMEs.

.Theoretical Background and Hypotheses

2.1 ESG and GI

ESG criteria encompass fundamental principles that serve as a critical framework for evaluating an organization's dedication to sustainable development and ethical practices (Peng, 2023). Despite a longstanding academic focus on ESG, significant gaps remain in our understanding of its conceptualization, motivations for its adoption, stakeholders' impacts, benefits, and future trajectory (Huang, 2021). In response to these gaps, there has been a marked increase in businesses' commitment to ESG initiatives aimed at recognizing their contributions to social responsibility (Kim & Li, 2021). This dedication is especially noticeable in organizations' increased emphasis on GI, which entails incorporating ESG elements and can markedly expedite the shift towards sustainable transformation (Liu & Lyu, 2022). Under China's dual-carbon strategy that seeks to promote green transformation, GI is increasingly aligned with the ESG framework. This alignment encourages the creation of thorough innovation strategies and governance approaches to tackle environmental challenges (Cao et al., 2024). Faced with the necessity to enhance ESG performance, some enterprises have demonstrated their capacity for GI to stakeholders by adopting strategies similar to those employed by other companies, thereby mitigating external risks and amplifying the positive impacts on their GI performance (Zhu & Yang, 2024). From the perspective of the RBV, sustained ESG engagement enables a firm to accumulate a stock of strategic resources, including environmental knowledge, green management routines, and trust from stakeholders, that are valuable, rare, and hard for competitors to imitate (Barney, 1991). These resources form the basis on which GI proceeds, because developing green products and cleaner processes draws directly on such knowledge and capabilities. Firms with stronger ESG performance can therefore mobilize more of the resources that GI requires, and their employees are more capable of engaging in GI. Based on the above reasoning, this study proposes:

Hypothesis 1

ESG will positively influence GI.

2.2 ESG and EI

EI includes the goods, offerings, and procedures embraced by organizations to promote environmental sustainability **(Pérez et al., 2020)**. This approach not only transforms organizations by reshaping their philosophies, values, and operations but also facilitates the development of products and practices that are economically beneficial as well as socially and environmentally progressive (Chukwuka & Nwomiko, 2018). The advantages of these initiatives extend to innovative companies and the society. Furthermore, ESG criteria have emerged as a pivotal management paradigm that positively impacts corporate

sustainability (Qing & Jin, 2023). Companies are increasingly adopting voluntary strategies driven by accountability to fulfill social responsibilities, reduce environmental impacts, and promote EI and sustainable growth. The integration of ESG criteria, informed by theories of eco-efficiency, EI, and ecological well-being, accelerates the dissemination of sustainable development concepts (Ragazou et al., 2024). The focus on ecological efficiency and sustainable innovation is crucial for promoting EI, furthering developmental objectives, and effectively tackling environmental issues. Technology companies exhibiting robust performance in ESG criteria are more likely to secure government grants and tax incentives. Compared with non-tech enterprises, financial advantages can serve as a driving force for such enterprises to promote EI (Zhang & Jin, 2022). Numerous public companies utilize ESG-oriented growth strategies to capitalize on their core resources and boost their competitiveness and performance. This subsequently promotes the advancement of EI technologies (Zheng et al., 2022). According to the RBV, the capabilities and legitimacy that firms accumulate through ESG practices, such as environmental expertise, governance routines, and credibility with regulators and consumers, are hard to replicate and can be redeployed to new uses (Barney, 1991). EI is a resource-intensive activity with high development costs, uncertain returns, and long cycles, so firms with richer ESG-derived resource endowments are better positioned to sustain such commitments and to convert environmental demands into innovation outcomes. On this basis, this study hypothesizes:

Hypothesis 2

ESG will positively influence EI.

2.3 GI and EI

GI represents a strategic methodology that merges environmental stewardship with innovative practices, with the objective of minimizing ecological footprints and elevating environmental sustainability (Hussain et al., 2024). The theory offers a structure for grasping how GI promotes waste management, treatment, recycling, water purification, and climate change alleviation, acting as the basis for eco - innovation and propelling sustainable development. GI includes technological improvements that help conserve energy and recycle waste materials (Huong et al., 2021). Recently, it has emerged as a priority in Asian economies, particularly those characterized by resource-intensive growth models (Tolliver et al., 2021). This change is a reaction to growing concerns from both the government and society regarding environmental damage (Song & Yu, 2018). The capacity of green technology companies to innovate by developing new and significantly enhanced products and services is crucial because it emphasizes EI within manufacturing processes (Rana et al., 2021). In China, scientists and engineers have enhanced firms' GI capacities and set up a robust national innovation framework that is crucial for sustainable growth and the nation's progress in EI (Zhen, 2011). Viewed through the RBV, GI is not only a set of outputs but also a process through which firms accumulate path-dependent green knowledge and innovation routines that competitors can hardly copy (Barney, 1991). EI asks firms to embed environmental considerations into products, processes, and business models, and this recombination

draws directly on the knowledge and capabilities accumulated through GI. Firms with stronger GI are therefore better equipped to turn environmental demands into eco-innovative outputs. Accordingly, this study hypothesizes:

Hypothesis 3

GI will positively influence EI.

2.4 The Mediating Effect of GI

As an essential element of ESG, GI serves to meet environmental obligations while simultaneously improving a company's environmental performance, thus fostering the advancement of EI **(**Seman et al., 2019**)**. The core purpose of corporate ESG implementation is to address tensions between production activities, resources, and the environment and to attain extra profits through the beneficial impact of GI, thus driving EI and boosting corporate performance **(**Liu et al., 2022). ESG culture is vital for shaping employee awareness and engagement with GI and promoting commitment to ecological preservation and sustainability, which helps reduce environmental impacts **(García & Martínez, 2019)**. ESG principles encourage organizations to adopt GI practices, such as implementing EI processes that recycle waste and reduce the volume of toxic materials and waste **(**Shafique et al., 2017). GI, grounded in ESG principles, substantially reduces an organization's negative environmental impact while enhancing its EI performance. This study contends that the implementation of the RBV theory, which asserts that a firm's distinctive resources contribute to its competitive advantage, facilitates the capacity of ESG to compel organizations to prioritize their environmental and social obligations. Consequently, this emphasis fosters the adoption of GI strategies that are critical for addressing urgent environmental challenges. Additionally, it lays the groundwork for broader EI initiatives and aligns sustainable objectives with tangible environmental outcomes. Drawing on the theories elaborated above, this study formulates the subsequent hypotheses:

Hypothesis 4

GI will positively mediate the relationship between ESG and EI.

2.5. The Moderated Mediation Effects of TMEA

Environmental awareness encompasses the ideas, convictions, and outlooks regarding the natural world and its importance in human existence, held by specific social groups within a given historical context **(**Wielewska & Zuzek, 2015**)**. TMEA refers to the degree of top managers' engagement and concern regarding environmental issues **(**Anwar et al., 2024**)**. UET holds that organizational outcomes reflect the cognitive bases and values of top managers, who interpret strategic situations through these lenses **(**Hambrick & Mason, 1984**)**. TMEA can thus be read as the environmental dimension of this cognitive

base: it shapes how managers interpret ESG signals and how far they commit resources to GI. Therefore, this research argues that TMEA conditions the effectiveness of ESG and GI in promoting EI.

Employee EI in Chinese SMEs hence hinges on the interplay between ESG, GI, and TMEA. Once executives recognize the returns linked to environmental practices, companies become more proactive in GI activities and advance toward green development (Lin & Zhao, 2023). Managers with a deep understanding of environmental issues can plan and innovate processes and products more effectively than those lacking such awareness, and this consciousness spurs the advancement of GI (Cheng et al., 2023). The RBV adds that when management comprehends environmental protection and effectively identifies and utilizes the green resources offered by financial institutions, investors, and other stakeholders, the capacity for environmentally sustainable innovation is significantly enhanced (Tan & Zhu, 2022). In sum, when TMEA is high, ESG commitments are translated into GI with greater intensity, and employees' GI efforts are carried through to EI with higher quality.

ESG also links environmental innovation with waste management and encourages companies to reduce waste (Albitar et al., 2024), and it works through managers as much as through systems. UET implies that the strategic effect of ESG depends on who interprets it, since top managers with strong environmental consciousness are more likely to translate ESG commitments into environmental strategies and actions (Zhang et al., 2024). The policy environment reinforces this link. In January 2008, the Resources Management Committee of the State Council of China jointly promulgated guidelines on the disclosure of social responsibility information, which spurred enterprises' interest in issuing ESG reports and facilitated the integration of GI into corporate strategies (Rauf et al., 2024). ESG initiatives further help firms reduce risks and enter new markets through innovative approaches that conform to ESG standards (Trinh et al., 2024). GI, in turn, fosters ecological sustainability by enabling the development of environmentally friendly technologies and products, and this search for novel sustainable pathways enhances the distinctiveness of products and services in the realm of EI (Kuzior et al., 2022). Within Chinese SMEs, a higher degree of TMEA is therefore associated with a stronger influence of ESG and GI on employees' EI.

This study investigates GI as a mediating variable in the EI framework and identifies TMEA as a moderator of the relationships between ESG, GI, and EI. From the UET perspective, the mediating pathway from ESG through GI to EI passes through managers' environmental cognition, so its strength varies with TMEA. The hypotheses are as follows:

Hypothesis 5

TMEA will positively moderates the relationship between ESG and EI.

Hypothesis 6

TMEA will positively moderates the relationship between GI and EI.

Hypothesis 7

The mediating influence of GI on the relationship between ESG and EI is moderated by TMEA.

.Methods

3.1. Sample characteristics

This study investigation centers on individuals engaged in the domain of Chinese SMEs and collects data via the deployment of an electronic survey tool (SoJump). For data collection, we used snowball sampling to distribute our research questionnaire to SME members within our professional network. This approach relied on colleagues employed by these organizations to forward the survey. We targeted individuals with whom we had professional connections, asked them to complete the survey, and invited their colleagues to complete the survey. Our survey included 371 participants from 29 SMEs in China. We ensured the confidentiality of all participants to ensure data authenticity and requested their participation in the survey.

The data procured throughout the research initiative were designated exclusively for the purposes of this particular investigation, with a stringent prohibition on divulging them to any external party. The study was conducted over a 14-day period, commencing on the 8th of September 2024 and concluding on the 21st of September 2024, ultimately amassing 371 data samples. Before starting the survey, we explained the contents of the questionnaire to the participants in advance. In particular, we explained that participation in the survey was voluntary and there was no compulsory participation whatsoever.

In this study, we implemented a retrospective screening and elimination process to identify and exclude uniform response sequences from the survey data. Uniform response sequences are characterized by participants providing answers that adhere to a specific, repetitive pattern or sequence, such as ‘11111’ or ‘12345’, which may not reflect genuine contemplation or lived experience. In order to mitigate the potential for data contamination and uphold the integrity of our findings, we adopted specific strategies to tackle this issue (Peterson & Griffith, 2006). Following the exclusion of 42 questionnaires that exhibited either highly similar responses or abnormally short completion times, the dataset available for analysis was subsequently reduced to 329. For the questionnaire response rate to serve as a dependable foundation for conclusions, it should ideally exceed 70%, and in this research, it achieved 88.67%. Therefore, the response rate was deemed satisfactory.

Using G*Power 3.1 software for statistical power computation (Faul et al., 2007), a power analysis was performed. In the analytical stage, the significance level was set at $\alpha = 0.05$, signifying statistical relevance, and the effect size was determined to be $f = 0.15$, suggesting a moderate influence. The unidirectional predictor under scrutiny was one, namely, the EI variable. The total number of predictors includes three components: the independent variable, the mediating variable, and the moderating variable, which relate to ESG, GI and the TMEA. A power analysis indicated that a minimum sample size of 89 participants was necessary to attain a statistical power of 95%. In order to build a reliable dataset for analysis, a sample size of 329 participants was ultimately used in this study, which significantly

exceeded the 89 recommended by the power analysis. Therefore, the sample size used in this study is considered sufficient and meets the standards needed to conduct a comprehensive analysis.

Regarding the demographic characteristics of the participants in this research, the distribution is as follows: 172 males (representing 52.3% of the total sample) and 157 females (constituting 47.7%). In terms of age distribution, the study included 22 participants (6.7%) in the 20 years and below age group, 106 (32.2%) in the 20–29 age range, 86 (26.1%) in the 30–39 age bracket, 69 (21%) in the 40–49 age category, and 46 (14%) who were 50 years or older. Regarding educational qualifications, the survey revealed that 36 (10.9%) had completed technical or secondary education, 93 (28.3%) held associate degrees, 114 (34.7%) had obtained bachelor's degrees, 46 (14%) possessed master's degrees, and 40 (12.2%) had achieved doctoral degrees or higher levels of education. Concerning tenure, the survey indicated that 51 (15.5%) had been in their current employment for less than a year, 66 (20.1%) for 1 to 2 years, 45 (13.7%) for 3 to 5 years, 100 (30.4%) for 5 to 7 years, and 67 (20.4%) for more than 7 years. Lastly, concerning the sector of employment, the findings showed that 60 participants (18.2%) were in the educational sector, 83 (25.2%) were in the financial sector, 57 (17.3%) were in the coal mining sector, 89 (27.1%) were in the catering services sector, 32 (9.7%) were in the healthcare sector, and 8 (2.4%) were in other industries.

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3.2. Measurement

ESG pertains to the criteria encompassing ESG aspects, employed to evaluate corporate performance in terms of ecological preservation, societal accountability, and administrative management (Han et al., 2023). This study utilized 15 metrics from Barbosa et al. (2024) to measure the ESG of Chinese SMEs. The scale used in the research remained consistent and unaltered throughout the investigation. Sample items included 'In your perception, does the organization implement initiatives to reduce energy consumption?' or 'In your perception, does the organization implement initiatives to fight corruption?'.

GI denotes advancements in technology that address negative environmental impacts, conventional energy usage, and waste management (Zheng et al., 2023). This study adopted the scale proposed in Wang et al.'s (2020) research, which consists of 8 items, to measure GI in Chinese SMEs. The scale used in the investigation remained consistent and unaltered throughout the research process. Sample items included 'Our firm actively strengthens current green technology'. or 'Our firm actively discovers new green market.'.

The TMEA encompasses the degree of understanding and commitment to environmental issues that top-level management develops during their cognitive deliberations (Cao et al., 2022). To quantify the TMEA practices within Chinese SMEs, this research adopted 3 metrics as outlined in the research by Zhao et al. (2024). Throughout the study's investigation process, the scale remained unchanged, maintaining its original form. Sample items included 'Our executives are aware of the best environmental practices in the industry'. or 'Our executives are aware of the impact of environmental regulations on our company.'.

EI encompasses a spectrum of innovative activities aimed at environmental improvement, including the development of novel techniques, methodologies, products, services, and business models (Jo et al., 2015). This research utilized four metrics, as outlined in the study by Zhao et al. (2024), to assess EI in Chinese SMEs. The scale used in the investigation remained consistent and retained its original structure throughout the study. Sample items included 'Our unit often improves the production process to reduce environmental pollution.' or 'Our unit often introduces new technologies in the production process to save energy.'.

Participants evaluated each statement on a 7-point Likert scale, where 1 indicates strong disagreement and 7 indicates strong agreement. Utilizing the previously mentioned variables and the framework of the PROCEE model, this study develops its particular model, illustrated in Fig. 1.

. Results

4.1. Exploratory factor analysis

EFA serves as a technique to check whether the variables intended for assessment can be grouped into core factors by applying suitable evaluation methods and tools (Jin, 2019). Table 1 presents the results of the EFA.

In the research, four independent factors were identified: ESG, GI, TMEA, and EI. ESG, encompassing 15 items, had factor loadings between .834 and .874 for factor 1. GI, with 8 items, saw loadings from .841 to .873 for factor 2. TMEA, comprising 3 items, had loadings ranging from .853 to .865 for factor 3. Lastly, EI, with 4 items, exhibited loadings between .864 and .882 for factor 4. Each factor's loadings surpassed the .5 threshold.

Table 1
The result of exploratory factor analysis

Variable	Item	Component			
		1	2	3	4
ESG	1	.851	.145	.085	.094
	2	.870	.088	.048	.069
	3	.850	.115	.098	.122
	4	.859	.157	.063	.106
	5	.844	.131	.144	.144
	6	.849	.089	.084	.153
	7	.862	.141	.053	.126
	8	.869	.119	.136	.068
	9	.834	.152	.097	.145
	10	.874	.150	.063	.072
	11	.835	.137	.088	.116
	12	.853	.147	.106	.119
	13	.843	.133	.019	.067
	14	.834	.122	.064	.145
	15	.843	.110	.126	.124
GI	1	.150	.848	.094	.082
	2	.139	.869	.122	.008
	3	.180	.849	.140	.087
	4	.153	.867	.065	.073
	5	.133	.864	.132	.055
	6	.130	.844	.160	.042
	7	.136	.841	.110	.065
	8	.144	.873	.095	.087
TMEA	1	.228	.152	.097	.859
	2	.244	.080	.084	.865
KMO=.959(sig=.000)					

Variable	Item	Component			
		1	2	3	4
	3	.274	.107	.119	.853
EI	1	.115	.180	.864	.098
	2	.128	.174	.879	.088
	3	.159	.154	.882	.045
	4	.136	.195	.867	.081
Eigenvalues		13.657	5.232	2.625	1.878
Dispersion(%)		45.524	17.439	8.750	6.259
Cumulative(%)		45.524	62.964	71.714	77.973
KMO=.959(sig=.000)					

4.2 Confirmatory Factor Analysis

CFA is employed to assess the structural soundness and dimensional uniformity of the latent constructs (Sidharta, 2018). This research used AMOS 23.0 to evaluate six models in sequence, all significant at $p < 0.001$. Model 1, the hypothesized model in which ESG, GI, TMEA, and EI were assessed as four independent constructs, produced the best fit, $X^2=798.445$, $X^2/df = 2.074$, RMSEA = 0.057, IFI = 0.959, CFI = 0.958, PNFI = 0.817, PGFI = 0.709. Model 2, which loaded all items on a single factor, yielded $X^2=4426.518$, $X^2/df = 10.903$, RMSEA = 0.174, IFI = 0.596, CFI = 0.595, PNFI = 0.534, PGFI = 0.353. Model 3, combining ESG with GI as Factor 1 and TMEA with EI as Factor 2, returned $X^2=3654.564$, $X^2/df = 9.001$, RMSEA = 0.156, IFI = 0.673, CFI = 0.672, PNFI = 0.604, PGFI = 0.393. Model 4, pairing ESG with TMEA as Factor 1 and GI with EI as Factor 2, returned $X^2=2162.393$, $X^2/df = 5.326$, RMSEA = 0.115, IFI = 0.823, CFI = 0.823, PNFI = 0.738, PGFI = 0.599. Model 5, with three factors of ESG, EI, and GI combined with TMEA, returned $X^2=1416.294$, $X^2/df = 3.497$, RMSEA = 0.087, IFI = 0.898, CFI = 0.898, PNFI = 0.804, PGFI = 0.804. Model 6, grouping ESG with TMEA as Factor 1, GI as Factor 2, and EI as Factor 3, returned $X^2=1316.778$, $X^2/df = 3.251$, RMSEA = 0.083, IFI = 0.908, CFI = 0.908, PNFI = 0.813, PGFI = 0.69. Overall, Model 1 aligned with the data best. Table 2 summarizes the fit indices of each model.

Table 2
Summary of structural model fit results.

Model	$\chi^2(p)$	χ^2/df	RMSEA	IFI	CFI	PNFI	PGFI
Model 1 (Expected Model of four-factor a)	798.445(0.000)	2.074	0.057	0.959	0.958	0.817	0.709
Model 2 (one-factor b)	4426.518(0.000)	10.903	0.174	0.596	0.595	0.534	0.353
Model 3 (two-factor c)	3654.564(0.000)	9.001	0.156	0.673	0.672	0.604	0.393
Model 4 (two-factor d)	2162.393(0.000)	5.326	0.115	0.823	0.823	0.738	0.599
Model 5 (three-factor e)	1416.294(0.000)	3.497	0.087	0.898	0.898	0.804	0.673
Model 6 (three-factor f)	1316.778(0.000)	3.251	0.083	0.908	0.908	0.813	0.690

Note: [a]=ESG, GI, TMEA, and EI. [b]=All items were loaded on a single factor. [c]=ESG and GI, TMEA and EI. [d]=ESG and TMEA, GI and EI. [e]=ESG, EI, GI and TMEA. [f]=GI, EI, ESG and TMEA.

The CFA results for the four-factor Model 1 confirmed construct validity. For convergent validity, the standardized regression coefficients ranged from 0.692 to 0.837 for ESG, 0.730 to 0.829 for GI, 0.605 to 0.998 for TMEA, and 0.660 to 0.851 for EI. The AVE values were 0.654 for ESG, 0.641 for GI, 0.640 for TMEA, and 0.641 for EI, all above the 0.5 threshold, and the CR values were 0.919, 0.862, 0.789, and 0.726 respectively, all above the 0.7 threshold. The fit indices fell into three categories. Absolute fit indices were $\chi^2=798.445$ ($p < 0.001$), $\chi^2/df = 2.074$, and RMSEA = 0.057, incremental fit indices were IFI = 0.959 and CFI = 0.958, and parsimonious adjusted fit indices were PGFI = 0.709 and PNFI = 0.817. Together these results support the acceptability of the measurement model. Table 3 reports the detailed results on convergent validity.

Table 3
The Result of Confirmatory Factor Analysis

Variables		Estimate	S.E.	C.R.	*p*	Standardized Regression Weights	AVE	C.R
ESG	A15	1			***	.692	.654	.919
(A)	A14	1.269	.059	21.689	***	.796		
	A13	1.158	.054	21.348	***	.786		
	A12	1.347	.058	23.050	***	.826		
	A11	1.241	.057	21.702	***	.796		
	A10	1.315	.056	23.575	***	.837		
	A9	1.3	.058	22.284	***	.809		
	A8	1.373	.058	23.635	***	.836		
	A7	1.354	.058	23.311	***	.829		
	A6	1.276	.057	22.460	***	.811		
	A5	1.295	.056	23.018	***	.823		
	A4	1.318	.057	23.246	***	.828		
	A3	1.346	.059	22.885	***	.823		
	A2	1.308	.058	22.579	***	.816		
	A1	1.323	.059	22.613	***	.817		
GI	B8	1				.730	.641	.862
(B)	B7	1.154	.054	21.438	***	.785		
	B6	1.223	.056	22.038	***	.801		
	B5	1.261	.054	23.184	***	.821		
	B4	1.22	.053	23.053	***	.822		
	B3	1.314	.057	23.163	***	.825		
	B2	1.343	.058	23.298	***	.829		
	B1	1.228	.056	21.890	***	.792		
TMEA	C3	1				.605	.640	.789
(C)	C2	1.260	.175	7.2190	***	.747		

Variables		Estimate	S.E.	C.R.	*p*	Standardized Regression Weights	AVE	C.R
	C1	1.679	.139	12.051	***	.998		
EI	D1	1				.660	.641	.726
(D)	D2	1.388	.063	21.889	***	.826		
	D3	1.429	.064	22.395	***	.850		
	D4	1.492	.066	22.501	***	.851		
Model Fit Index		$X^2(p)$ = 798.445(.000), X^2/df = 2.074, RMSEA=.057, IFI=.959, CFI=.958, PGFI=.709, PNFI=.817						

4.3 Reliability Analysis

A reliability analysis evaluates the dependability and consistency of evaluative instruments and criteria, ensuring that participant responses demonstrate stable patterns over time or across different contexts **(**Yang, 2015**)**. This study employs Cronbach's alpha to measure the reliability of the variables. The results of the reliability analysis are outlined below. Initially, the ESG assessment consisted of 15 items, yielding a Cronbach's alpha of 0.978. The assessment of employees' GI included eight items, resulting in a Cronbach's alpha of 0.958. To evaluate TMEA, three items were utilized, which produced a Cronbach's alpha of 0.893. Finally, the EI assessment comprised four items, achieving a Cronbach's alpha of 0.926. All Cronbach's alpha values exceeded the threshold of 0.7, thereby confirming the reliability and validity of the variables.

4.4 Descriptive Statistics and Correlation Analysis

Table 4 summarizes the descriptive statistics and correlations. The means of ESG, GI, TMEA, and EI were 5.019, 4.998, 4.970, and 4.750, with SDs of 1.594, 1.550, 1.688, and 1.738. All correlations among the variables were positive and significant ($p < 0.001$). ESG correlated with GI (r=.328), TMEA (r=.417), and EI (r=.280); GI correlated with TMEA (r=.249) and EI (r=.347); and TMEA correlated with EI (r=.253). These positive associations are consistent with the direction of the hypothesized relationships among ESG, GI, and EI.

Table 4
The Results of Descriptive Statistics and Correlation Analysis

Variables	Mean	SD	ESG	GI	TMEA	EI
ESG	5.019	1.594	-			
GI	4.998	1.550	.328***	-		
TMEA	4.970	1.688	.417***	.249***	-	
EI	4.750	1.738	.280***	.347***	.253***	-

***:p<.001.

4.5 Discriminant Validity Assessment Methods

Table 5 displays the discriminant validity test results. The results show that the AVE for ESG is 0.654, exceeding the squared correlation coefficients (r^2) of the other constructs, which are 0.090, 0.069, and 0.049. The AVE for TMEA was 0.640, exceeding the r^2 values with other dimensions, which were recorded as 0.090, 0.034, and 0.026. The AVE for GI is 0.641, which is higher than the r^2 values for the other dimensions (0.069, 0.034, and 0.087). Similarly, the AVE for EI is 0.641, outperforming the r^2 values of the other dimensions, which are 0.049, 0.026, and 0.087, respectively. Given that all AVE values for these variables exceeded their respective r^2 values, we can confidently conclude that discriminant validity was established.

Table 5
The Results of Discriminant Validity

Variables	ESG	TMEA	GI	EI
ESG	(.654)			
TMEA	.300(.090)	(.640)		
GI	.263(.069)	.186(.034)	(.641)	
EI	.223(.049)	.164(.026)	.295(.087)	(.641)

In the current investigation, the Heterotrait-Monotrait Ratio (HTMT) inference method was employed to assess the discriminant validity among the constructs related to ESG, TMEA, GI, and EI. To establish discriminant validity, it is essential that HTMT values remain below the critical threshold of 0.85, as suggested by Henseler et al. (2015). As demonstrated in Table 6, all HTMT values fall below this specified threshold. Additionally, HTMT inference was conducted utilizing bootstrapping with 5000 samples. Discriminant validity is confirmed when the resulting confidence interval does not exceed 1. The results presented in Table 8 provide empirical evidence supporting the presence of discriminant validity within this framework. In addition, the results of HTMT inference is presented in the Table 7.

Table 6
The Results of Heterotrait-Monotrait ratio (HTMT)

Variables	ESG	TMEA	GI	EI
ESG	-			
TMEA	0.447	-		
GI	0.339	0.269	-	
EI	0.294	0.278	0.368	-

Table 7
The Results of HTMT inference

ESG → TMEA	Original data (O)	Data average (M)	5.0%	95.0%	Data average (M)	Bias	5.0%	95.0%
	0.447	**0.447**	**0.334**	**0.56**	**0.447**	**0**	**0.334**	**0.559**
ESG → GI	0.339	0.339	0.232	0.45	0.339	0	0.232	0.45
TMEA → GI	0.269	0.27	0.155	0.385	0.27	0.001	0.153	0.383
ESG → EI	0.294	0.294	0.184	0.401	0.294	0	0.184	0.399
TMEA → EI	0.278	0.277	0.16	0.394	0.277	-0.001	0.163	0.396
GI → EI	0.368	0.367	0.257	0.468	0.367	-0.001	0.256	0.467

4.6 Hypothesis Test

This research formulated seven hypotheses. Initially, it validated the impact of ESG factors on employee engagement in GI initiatives. Subsequently, it examined the relationship between ESG and the propensity for EI. The third dimension of the study assessed the role of GI in enhancing employees' EI efforts. Additionally, the research analyzed the potential mediating effect of GI on the relationship between ESG and EI. To empirically evaluate these hypotheses, path analysis was performed utilizing Amos version 23.0, with the results detailed in Table 8.

Hypothesis 1

proposes that ESG positively impacts GI. The analysis indicates a significant positive impact of ESG on GI (estimate=.329, p<.001), thus supporting Hypothesis 1. This suggests that ESG induces GI among employees.

Hypothesis 2

posits that ESG positively impacts employee EI. The results reveal a significant positive effect of ESG on employee EI (estimate=.196, p<.001), thereby supporting Hypothesis 2. This explains why ESG induces EI among employees.

Hypothesis 3

posits that GI exerts a positive influence on employee EI. The analysis demonstrates a significant positive relationship between GI and employee EI (estimate=.314, p<.001), thereby providing support for Hypothesis 3. This finding indicates that GI fosters EI among employees.

Hypothesis 4

examined the mediating role of employees' GI in the relationship between ESG factors and EI. The analysis revealed an indirect effect of .003, with a LLCI of .056 and an ULCI of .161. Given that the interval between the Boot LLCI and Boot ULCI does not encompass zero, the mediating effect is deemed statistically significant. Consequently, Hypothesis 4 is supported.

Table 8
The results of path analysis

Path			**Estimate**	**S.E.**	**C.R.**	**p**
ESG	→	GI	0.329	0.054	6.071	***
ESG	→	EI	0.196	0.059	3.339	***
GI	→	EI	0.314	0.062	5.078	***
Indirect Effect			Effect	Boot LLCI	Boot ULCI	
ESG → GI → EI			.003	.056	.161	
Model Fit Index	$X^2(p) = 525.65(.000)$, $X^2/df = 1.638$, RMSEA=.044, IFI=.978, CFI=.978, PGFI=.757, PNFI=.864					
***:**p<.001**, **:**p<.01**, *:**p<.05**, †**= p<.1**						

Hypotheses 5 and 6 investigated the influence of TMEA as a moderating variable in the relationship between ESG/GI and EI. To evaluate these hypotheses, a multiple regression analysis was performed using SPSS version 26.0.

Hypothesis 5

posits that the TMEA serves as a moderating factor in the relationship between ESG criteria and EI (Table 9). However, the results of the analysis reveal that this awareness does not significantly moderate the relationship, as indicated by a beta coefficient of $\beta = 0.002$ and a p-value greater than 0.1. Consequently, Hypothesis 5 is rejected, suggesting that the degree of TMEA does not enhance the positive impact of ESG on EI.

Table 9
The Result of Moderation (ESG)

Dependent Variable: EI							
	Model 1		**Model 2**		**Model 3**		
	β	**t**	**β**	**t**	**β**	**t**	**VIF**
ESG (A)	0.280***	5.269	0.211***	3.647	0.211**	3.529	1.297
TMEA (B)			0.165**	2.857	0.165**	2.850	1.216
Interaction (A*B)					0.002	0.039	1.107
R^2(Adjusted R^2)	0.078(0.075)		0.101(0.095)		0.101(0.092)		
⊿R^2 (⊿Adjusted R^2)	-		0.023(0.355)		0.000(-0.003)		
F	27.761***		18.266***		12.140***		
***:**p<.001**, **:**p<.01**, *:**p<.05**, †**= p<.1**							

Hypothesis 6

posits that the TMEA serves as a moderating variable in the relationship between GI and EI. The results demonstrated a significant moderating effect of TMEA (β = .094, p<.1), thereby supporting the validity of Hypothesis 6. Table 10 presents the comprehensive results of the moderation analysis regarding TMEA. Figure 2 illustrates the moderating effect, showing that higher levels of GI correlate with greater EI, especially when TMEA is perceived to be high.

Table 10
The Result of Moderation (GI)

Dependent Variable: EI							
	Model 1		**Model 2**		**Model 3**		
	β	**t**	**β**	**t**	**β**	**t**	**VIF**
GI (A)	0.347***	6.682	0.302***	5.735	0.313***	5.918	1.078
TMEA (B)			0.178**	3.376	0.184**	3.492	1.070
Interaction (A*B)					0.094†	1.822	1.020
R^2(Adjusted R^2)	0.120(0.117)		0.150(0.145)		0.158(0.151)		
ΔR^2 (ΔAdjusted R^2)	-		0.030(0.028)		0.008(0.006)		
F	44.651***		28.733***		20.398***		
***:**p<.001**, **:**p<.01**, *:**p<.05**, †**= p<.1**							

Table 11 reports the moderated mediation analysis for TMEA. The conditional indirect effect was 0.0579 (bootstrapped SE = 0.0300, CI [0.0044, 0.1221]) at one standard deviation below the mean, 0.0993 (SE = 0.0262, CI [0.0538, 0.1552]) at the mean, and 0.1408 (SE = 0.0380, CI [0.0746, 0.2202]) at one standard deviation above the mean. None of these intervals included zero, and the effect increased steadily as TMEA rose. The index of moderated mediation was 0.0246 (SE = 0.0130, CI [0.0009, 0.0516]), which also excluded zero. The moderated mediation effect of TMEA was therefore significant, supporting Hypothesis 7.

Table 11
The moderated mediation effect of TMEA

Dependent Variable: EI					
Moderator	Level	Conditional Indirect Effect	Boot SE	Boot LLCI	Boot ULCI
TMEA	−1 SD (− 1.6885)	.0579	.0300	.0044	.1221
	M	.0993	.0262	.0538	.1552
	+ 1 SD (+ 1.6885)	.1408	.0380	.0746	.2202
Index of moderated mediation					
	Index		Boot SE	Boot LLCI	Boot ULCI
	.0246		.0130	.0009	.0516

.Conclusion

This research explores the relationship between ESG factors and EI, with a specific focus on sustainable outcomes for organizations. Grounded in RBV, it analyzes the function of GI as a mediating variable within the connection between ESG and EI. Additionally, drawing on UET, a moderated mediation model is utilized to assess the impact of TMEA on the interactions among ESG, GI, and EI. The findings present important implications for future research and the sustainable development of SMEs in China, thereby contributing to their strategic planning efforts. The key conclusions of the study are:

5.1. Theoretical Implications

First, GI serves as a partial mediator in the relationship between ESG criteria and employee EI. This indicates that ESG criteria have both a direct impact on EI and an indirect effect mediated by the GI efforts of employees. The ESG framework facilitates startups in achieving GI by promoting environmentally sustainable practices across diverse ecological contexts, with the latter providing significant cost-effectiveness and practical advantages for entrepreneurial enterprises. In turn, this fosters ecological innovation and enhances the overall health and biodiversity of ecosystems (Asad et al., 2024). The ESG framework offers a comprehensive perspective on sustainable development for both businesses and employees. Within this framework, employees are urged to embrace eco-friendly practices. The improvement of both individual and team dynamics not only promotes GI but also aids in the advancement of sustainable technologies, products, and services. These innovations play a crucial role in conserving natural resources and mitigating a company's environmental footprint. As GI evolves, employees increasingly consider broader ecological implications, thereby further advancing this

initiative. EI encompasses the creation of novel business models and ecosystems that promote biodiversity, enhance resource efficiency, and improve the overall health of ecosystems. Consequently, ESG criteria not only nurture environmental accountability within individual organizations but also encourage the sustainable development of the entire ecosystem. Consequently, GI may function as a partial mediator in the association between ESG criteria and EI. Furthermore, EI, as a critical component, significantly enhances sustainable outcomes for organizations.

Second, the TMEA does not moderate the relationship between ESG factors and GI. Correlation analysis reveals a positive association between ESG and GI, as well as between ESG and the TMEA. Furthermore, there exists a positive correlation between the environmental awareness of top management and GI. Nevertheless, the findings presented in Table 9 suggest that the interactive effect of ESG and TMEA is not particularly robust. While the environmental consciousness of senior management is essential for fostering a company's GI and sustainable development, it may not directly impact the relationship between ESG factors and employees' contributions to GI. This constraint arises from the understanding that ESG represents an extensive framework that includes a corporation's environmental management, social accountability, and governance practices, which generally function at the organizational level. In contrast, employee GI is driven by individual behaviors. Although the TMEA may indirectly encourage GI by shaping a company's strategic choices and resource distribution, this influence may not be enough to directly change employees' innovative actions in their daily tasks. Moreover, a range of factors, including personal values, organizational culture, incentive structures, and individual competencies, can influence employees' engagement in GI, frequently operating independently of ESG criteria and the environmental consciousness of top management. Therefore, while the environmental consciousness of senior executives is essential to a company's comprehensive strategy for GI, it may not serve as a substantial moderating variable that directly influences the relationship between ESG factors and employee-driven GI.

Third, the TMEA serves as a moderating factor for green and EI. The correlation analysis indicates that there are positive associations among GI, the TMEA, and EI. As illustrated in Table 10 and Fig. 2, a significant interactive effect of GI on the TMEA is evident. This awareness is essential for decision-making and influences companies' investment levels in environmental information disclosure, GI, and other related areas (Ma et al., 2019). Furthermore, the implementation of an ambidextrous approach to GI not only increases the likelihood of successful EI but also necessitates that practitioners enhance their managerial competencies to adeptly navigate the balance between exploratory and exploitative strategies amidst complexities and uncertainties (Kim et al., 2024). Thus, irrespective of the level of TMEA being high or low, its interaction with GI can boost EI, with higher levels of environmental awareness having a greater impact than lower levels. Thus, TMEA serves as a pivotal factor in catalyzing GI, which in turn sets the stage for EI. When top managers prioritize and embody environmental responsibility, they set a precedent that permeates organizational culture. This cultural shift motivates staff to generate original ideas regarding sustainability, which can result in business practices and products being transformed. The TMEA plays a crucial role in aligning the organization's objectives with environmentally sustainable goals, thereby establishing a strong foundation for sustainable

development. Consequently, this alignment improves the SMEs ability to achieve its sustainability objectives and promotes the advancement of EI.

Fourth, this study investigated the extent to which TMEA influences the mediating effect of GI. The findings reveal that TMEA significantly moderates the mediation process. This outcome matches the anticipated results. TMEA significantly influences their investment and success in GI. This awareness is directly related to the practical implementation of ESG principles in EI. Specifically, when top managers have a profound understanding of environmental protection, they are more inclined to guide companies towards adopting proactive GI strategies. These strategies both improve the company's ESG performance and boost EI. GI effectively translates the concepts and objectives of ESG into tangible products, services, and process innovations. TMEA amplifies this translation process, enabling companies to achieve both environmental and social sustainability while simultaneously pursuing economic gains. Consequently, the TMEA plays a significant role in strengthening the relationship between ESG factors and EI, as it facilitates the implementation of GIs. This study employs a multifaceted approach to investigate the moderated mediating effect of TMEA, thereby laying the groundwork for future research and the development of more effective strategies to foster EI.

Fifth, this study contributes to theory by integrating the RBV and UET into one framework. For the RBV, the findings extend the theory into the sustainability context by treating ESG as a strategic resource stock rather than a compliance cost. The confirmed pathway from ESG through GI to EI depicts a complete resource chain in which resources are first accumulated, then converted into innovation capabilities, and finally realized as eco-innovative outputs. This adds to the understanding of how intangible and legitimacy-based resources generate competitive advantage. For UET, the results clarify the boundary conditions of managerial cognition. TMEA moderates the second stage of the mediation, from GI to EI, but not the first stage, from ESG to GI. This pattern suggests that managerial cognition matters most where strategic judgment and resource commitment are required, such as pushing green achievements toward eco-innovative outcomes, whereas the transmission from ESG to GI operates largely at the organizational level and is less sensitive to individual cognition. Read together, the two theories offer complementary explanations: the RBV explains where resources come from and how they are converted, while UET explains why the conversion efficiency differs across firms. This integration provides a resource and cognition perspective for future research on corporate sustainability.

In addition to the theoretical perspectives previously discussed, the results of this study indicate that ESG factors have a positive impact on GI, aligning with the findings of Li et al. (2023). Moreover, this research substantiates the affirmative effect of ESG on employee EI and underscores the beneficial role of GI in promoting employee EI. Ultimately, this study corroborates the mediating role of GI and the moderated mediation effect of TMEA.

5.2. Practical Implication

First, ESG practices are being implemented by Chinese SMEs, and the results confirm that ESG positively influences employees' GI and EI. Since the United Nations introduced ESG in 2004, it has become a key

international benchmark for measuring corporate sustainable development (Gao & Zhao, 2024). Managers therefore need a clear understanding of ESG benefits for stakeholders, including employees, investors, and the broader community, because ESG practices align business operations with ecological preservation, resource efficiency, and climate change mitigation and are vital for the sustained viability of firms and the planet.

Second, GI undertaken by employees is a key driver in promoting EI. Premier Li Keqiang stressed in the 2018 government work report that businesses should take the lead in technological innovation while the government supports the development of a GI ecosystem, reflecting the urgent policy focus on corporate GI (Zhang et al., 2023). Employees' environmentally friendly innovations raise awareness of environmental issues and foster sustainable practices, and green training together with incentive mechanisms can motivate employees to develop and implement green solutions across the organization.

Third, cultivating TMEA among top managers of Chinese SMEs is essential. As environmental awareness grows, top management develops a stronger sense of duty toward GI and devotes more resources and effort to it (Huang et al., 2020). Concrete measures include integrating environmental education into leadership training, rewarding green practices through financial incentives and recognition, fostering a culture of sustainability, and providing top managers with tools to measure and track the environmental impacts of operations. Collaboration with industry peers and participation in sustainability networks can further expose them to best practices in environmental management. With stronger environmental consciousness at the top, SMEs can build more sustainable business models and contribute to China and the global environment.

Fourth, enhancing the adoption of EI is crucial. Cultivating employees' environmental consciousness and encouraging their participation create an internal atmosphere that supports a company's EI efforts (Du et al., 2024). Firms can develop training programs that explain the value of sustainability and equip employees with green skills, and establish concrete incentives and recognition for eco-friendly initiatives so that employees actively participate in and lead EI projects.

Fifth, firms should manage ESG as a strategic resource rather than a set of compliance tasks. Following the RBV logic confirmed in this study, the value of ESG lies in the resources it accumulates, so firms are advised to identify, retain, and deploy these assets in a deliberate way, including building an inventory of environmental knowledge and green capabilities, channeling stakeholder trust into long-term innovation projects, and protecting green routines from short-term cost pressure. Since TMEA determines how efficiently these resources are converted into EI, managerial cognition should be anchored in organizational routines, for example by putting environmental performance on board agendas, incorporating environmental criteria into executive appraisal and promotion, and reporting green innovation progress regularly. With these mechanisms in place, ESG resources and managerial awareness can work jointly rather than separately, helping SMEs turn sustainability commitments into steady EI outputs.

Finally, this study also considers its implications for societal and disciplinary growth. ESG criteria, GI, TMEA, and EI together offer SMEs a framework for aligning operations with sustainable development objectives, improving their social license to operate, and attracting investment from environmentally aware stakeholders. GI helps SMEs secure competitive advantage while addressing environmental challenges, and senior management needs a forward-looking perspective to build an environment that promotes EI among employees. These elements jointly nurture a more sustainable and innovative business ecosystem for SMEs.

5.3. Limitations and Future Research

This study has several limitations. First, TMEA did not moderate the relationship between ESG and EI, and future research could revisit this result with longitudinal or qualitative designs and with new theoretical frameworks across industry contexts. Second, ESG was the only independent variable examined, whereas digital transformation (Xu et al., 2023), organizational innovation (Rodríguez-Rebés et al., 2021), and the open-innovation determinants of EI proposed by Sanchez-Henriquez and Pavez (2021) based on 3,047 companies in Chile offer alternative antecedents worth testing. Third, GI was modeled as a mediator, but it can also act as a moderator, as Razaq (2020) showed in a study of 110 bank employees in Pakistan, so future studies could test the moderating role of GI in the link between ESG and EI. Fourth, only TMEA was examined as a moderator, while employees' environmental awareness deserves equal attention, as Yu and Li (2024) found among 321 Chinese employees that it mediated the relationship between organizational green culture and employee green behavior. Fifth, the data came solely from SME personnel in China, and extending the sample to SMEs in other countries and regions would clarify how cultural contexts shape the way the environmental consciousness of top managers and employees affects ESG and EI.

Declarations

Informed Consent:

Prior consent was obtained from all participants before conducting the survey.

Conflicts of Interest:

The authors declare no conflicts of interest.

Ethical approval:

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Liaodong University(Ethics Review No. LDU-REC-2025-005).

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Author Contribution

Conceptualization, Jiaxing Du and Wei Liu; Methodology, Xiu Jin and Wei Liu; validation, Xiu Jin; Formal Analysis, Xiu Jin; Data Curation, Jiaxing Du and Wei Liu; Writing—original Draft, Jiaxing Du; writing—review and editing, Xiu Jin; supervision, Xiu Jin and Wei Liu. All authors have read and agreed to the published version of the manuscript.

Data Availability

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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Figures

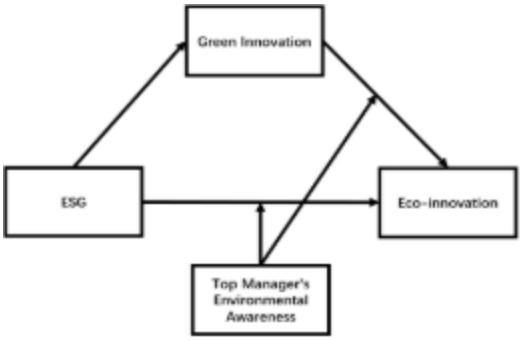


Figure 1

Research Model

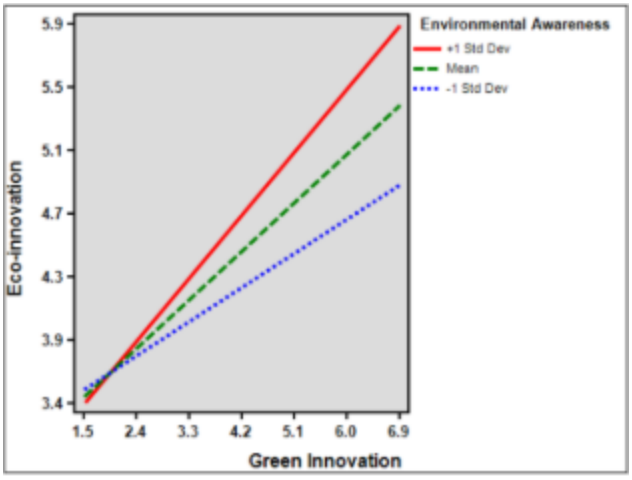


Figure 2

The moderating effect of TMEA (GI)