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RESEARCH ARTICLE

# Research on the Impact of Green Technological Innovation on Enterprise Internationalization: Mediated by Sustainable Development Performance

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**Abstract**
Against the backdrop of stringent global environmental governance and rising sustainability demands, green technology innovation has emerged as a pivotal strategic driver for firms seeking international expansion. Using panel data from Chinese listed companies (2012–2022), this study examines how green technology innovation influences both the breadth and depth of corporate internationalization, with a focus on the mediating role of sustainable development performance and the moderating effect of internalized advantages. The results demonstrate that green technology innovation significantly enhances internationalization breadth and depth, with both environmental and economic dimensions of sustainable development performance serving as key mediators. Internalized advantages further strengthen the relationship between green technology innovation and internationalization depth. Heterogeneity analysis reveals that non-state-owned enterprises and firms in capital- or technology-intensive industries benefit more substantially from green technology innovation in driving internationalization. These findings enrich the literature on green innovation and international business, while offering practical implications: Firms should strategically leverage green technology innovation to overcome trade barriers by developing green patent portfolios and aligning with international environmental standards. Policymakers are advised to foster cross-border recognition of green certifications through multilateral agreements, thereby reducing institutional transaction costs and facilitating the global diffusion of green technologies.

**Keywords**: Green technology innovation; Green patent; Enterprise internationalization; Environmental performance

## 1. Introduction

Despite the growth of the global economy over the past decades, over-consumption of resources and environmental problems, including climate change, acid rain, deforestation and water crises, have become more prominent. These issues have prompted countries to enact stringent environmental policies, requiring companies to take on more social responsibility while pursuing economic profits. Strict environmental regulations are not only a compliance requirement for enterprises, but also a driving force for technological innovation, which makes Green technology innovation one of the key means for enterprises to enhance their international competitiveness. Green technology innovation can not only optimise the efficiency of resource utilisation and significantly reduce

environmental pollution, but also help enterprises win competitive advantages in the global market through the development of green products and processes. Research indicates that green technology innovation manifests multidimensional value in the corporate internationalization process. It enables enterprises to better comply with environmental regulations in international markets and, through establishing green supply chains, improve resource utilization efficiency while reducing environmental burdens, thereby securing sustainable competitive advantages internationally (Silvestre, 2015). Xu Hui et al. (2025) conducted a longitudinal case study of Huayuan Industrial Group, a private Chinese steel enterprise, from the perspective of green affordance, exploring the dynamic process through which firms identify green opportunities in overseas markets within the context of carbon footprint management. The study reveals that green technological innovation serves not only as an adaptive strategy for enterprises to respond to international green trade barriers but also as a core proactive mechanism for actively identifying, shaping, and embedding themselves into the global green value chain. Simultaneously, growing global demand for eco-friendly products enhances the relevance of green technology innovation, allowing firms to capitalize on green consumption trends and elevate their social image and brand recognition. In international markets with strong environmental awareness, such enterprises gain greater consumer preference (De, 2012). Hu (2021), based on Chinese manufacturing enterprises from 2004 to 2010, found that green technology innovation enhances international competitiveness by breaking through green trade barriers and establishing differentiated advantages through the "innovation compensation" effect and the "responsibility awareness" effect. Corporate green technology innovation facilitates synergistic development across environmental, social, and economic dimensions (Barney, 1991; Elkington, 1998), thereby advancing sustainable development. Although existing studies have addressed green technology innovation's role in helping firms navigate environmental regulations and enhance competitiveness—including the innovation compensation hypothesis—a noticeable research gap remains in integrating green technology innovation with corporate internationalization and sustainable development performance from the perspective of resource integration and multidimensional performance (De, 2012; Braun & Wield, 1994).

In view of this，based on the resource-based theory and the triple bottom line theory, this study proposes the following research questions: First, does the impact of green technology innovation on the breadth and depth of corporate internationalization differ? Second, through what specific pathways and mechanisms does green technology innovation influence the corporate internationalization process? In particular, what mediating role do multidimensional performance indicators, represented by sustainable development performance, play in this relationship? Third, can firms effectively integrate and utilize the internalization advantages derived from green technology innovation to achieve synergistic development of environmental and economic performance, thereby ultimately driving their international expansion? Based on these three research questions, this study constructs a comprehensive analytical framework. First, it examines the direct effects of green technology innovation on the two distinct dimensions of corporate internationalization: breadth and depth. Subsequently, the study investigates the underlying mechanism by proposing sustainable development performance as a key transmission channel, thereby analyzing its mediating role in the relationship between green technology innovation and international expansion. Finally, the framework incorporates internalization advantages as a moderating variable, assessing how they condition the impact of green technology innovation on the depth versus breadth of internationalization.

## 2. Literature Review

### 2.1. Green Technology Innovation

Green technology innovation was first proposed by Braun and Wield in 1994, which is a general term that refers

to technologies, goods and/or processes that lower environmental damages and increase the utilization of energy(Linde, 1995).Currently, there is no unified standard for measurement of enterprises green technological innovation. There is a prevailing agreement that it encompasses dual aspects of input and output measurement. Horbach asserted in 2008 that green technology innovation must prioritize not only investment in research and development but also evaluate the outcomes of innovation, including the practical implementation of environmental protection technologies and the attainment of economic benefits(Rennings, 2000). For the aspects of input, researchers mainly focus on R&D expenditures, number of technical personnel, and external technological cooperation. De Marchi (2012) believed that the level of green technology innovation from firms' investment could be evaluated by the R&D expenditure amount to the total income which demonstrate the degree to which the investment is used for environmental technology R&D (De, 2012). While Rennings(2000) emphasized on the collaborations with research institutes and other companies which may yield the effectiveness of innovation investments. For the aspects of output, researchers usually use patent related data. Li Changying and Zhao Zhongtao proposed to use the number of citations as a measure of green patents instead of the number of patents in 2020(Wagner & Llerena, 2011). Cleff and Rammer believe that the number of patents is an intuitive reflection of Green technology innovation output at the same level, so as to help measure the success rate of firm technological development(Huang J C & Zhu G S, 2023). To address the constraints of a singular measurement approach, certain scholars have advocated for the utilization of multidimensional composite measurement techniques to more properly represent the comprehensive landscape of green technology advancement. In 2008, Horbach et al. emphasized that the assessment of green innovation output must account for the environmental advantages following technological implementation, including diminished pollutant emissions and enhanced energy efficiency (Horbach, 2008). However, although composite measurement methods are more comprehensive, their complexity significantly increases.

Therefore, in measuring green technology innovation, this article will be based on Cleff and Rammer's research, using patent data as the measurement method, in order to achieve the measurement of green technology innovation.

### 2.2. Enterprise Internationalization

The process of an enterprise's internationalization usually follows certain patterns(Johanson & Vahlne, 1977). Through continuous accumulation of resources and experience, the degree of internationalization expands both in breadth and depth.Scholars have engaged in extensive discourse over the breadth and depth of corporate internationalization, utilizing the Uppsala model as a framework for measurement. Hitt et al. (1997) contend that the breadth of internationalization pertains to the quantity and geographical dispersion of diverse markets a company penetrates, typically quantified by the number of countries housing the company's subsidiaries or the ratio of overseas subsidiaries to the total subsidiary count(Hitt, Hoskisson & Kim, 1997). Gomes and Ramaswamy (1999) further pointed out that the depth of internationalization can reflect the degree of operational dependence of enterprises in overseas markets, and commonly used indicators include the proportion of overseas revenue to total revenue and the proportion of overseas assets to total assets(Gomes & Ramaswamy, 1999). This type of dual dimensional measurement method has strong operability and can effectively evaluate the internationalization level of enterprises, but some scholars have pointed out that it has certain limitations. For example, Contractor et al. (2003) proposed an indicator based on the global network synergy effect of enterprises to evaluate the degree of resource integration of enterprises on a global scale(Contractor, Kundu & Hsu, 2003). Sullivan (1994) suggested using composite indicators to comprehensively measure internationalization, including the international experience of management teams, globalized product portfolios, and brand positioning(Sullivan,

1994). Although these composite indicators are more comprehensive, they also bring complexity to the weight distribution during data collection and measurement.
Therefore, when measuring the degree of internationalization of enterprises, this article will conduct empirical analysis on the breadth and depth of enterprise internationalization based on the research of Hitt et al. (1997) and Gomes and Ramaswamy (1999), aiming to achieve a comprehensive measurement of the degree of enterprise internationalization(Hitt et al, 1997; Gomes & Ramaswamy, 1999).

### 2.3. Green technology innovation and enterprise internationalization

Improving the level of green technology innovation for enterprises can reduce entry barriers in the process of internationalization facing more environmental regulations and market demands. For example, Mitsubishi Corporation conducts continuous technological research and development to adapt to the environmental challenges brought by environmental regulations in different countries. Mitsubishi meets the high environmental standards of the European Union by introducing and improving its Plug in Hybrid Electric Vehicle (PHEV) technology in markets that require higher environmental standards. This helps Mitsubishi better enter the European market and promote its internationalization process (Tomorrow, 2023). The research by Kim, Pantzalis, and Zhang (2021) proves that the development of green technology is a favorable factor for promoting the internationalization of enterprises. By establishing competitive advantages, improving product and service differentiation, and reducing compliance and operational risks, it not only enhances the internationalization ability of enterprises, but also enhances their long-term market value and cross-border cooperation (Kim et al. 2021).

### 2.4. Enterprises Sustainable Development Performance

The Corporate Sustainable Development Performance (CSDP) reflects the overall achievement of a company in economics, society and the natural environment and could be thought as a key measure of a company's social contribution for the society and environment beyond the maximizing the profit. Sustainable development performance, as a comprehensive indicator, encompasses the performance of an enterprise in terms of economy, society and environment. Xi Longsheng and Zhao Hui (2022) take into account financial performance and environmental performance as corporate sustainable development performance dimensions (Xi L S & Zhao H, 2022). In return on total assets is considered as financial performance indicator and social responsibility environmental score of listed companies on Hexun.com is regarded as the quantitative data of environment performance. According to the calculation result, the index obtained through the entropy weighting method is used as evaluation result for sustainable development performance of enterprises. Wang Aihua and Qi Haodong(2000) established an integral indicator that takes economic, social, and ecological advantage to make a distinction on the contribution of firms in the three areas to evaluate the degree of sustainable development (XXngA H & Ji H D, 2000). The merit of integral measurement models is to measure sustainable evaluation of firms on the level of economy, environment, and society which indicates CSDP evaluations are more flexible and precise. Meanwhile, such high complex computation and high requirements for data raise difficulty in application(Zhang & Qiang, 2019).
This article will assess sustainable development performance by evaluating basic economic performance through operating income and conducting daily research on environmental performance, with a focus on the environment and sustainability. A thorough assessment will be attained by evaluating the extent to which companies reveal their sustainable development statistics.

### 2.5 Green technology innovation Sustainable Development Performance and enterprise internationalization

Green technological innovation enhances the sustainable development performance of enterprises, thereby facilitating their internationalization process. Kang and Namkung (2018) also proposed that investing in environmental protection enables companies to stand out when entering new markets, especially in international markets with high standards and strict requirements. Such companies are more likely to gain consumer recognition and trus(Kang & Namkung, 2018). Huo et al. (2022) pointed out that companies with sustainable development and excellent environmental performance are more popular among consumers in the international market (Huo et al. 2022). The better sustainable development performance of the enterprise improves its compliance with the environmental requirements of the various countries engaged in cross-border cooperation and thereby reduces the compliance risks and barriers of entry. Miska et al. (2016) found that sustainable development performance of multinational enterprises has lowered entry barriers and allowed its free-flowing entry into markets with stricter environmental requirement in face of various environmental requirements (Miska, Witt & Stahl, 2016). Furthermore, Wagner (2011) revealed that firms with high sustainable performance are more compliant in the market and could be more flexible and adaptable to apply to environmental legislation of different countries by changing their products and production modes quickly. This adaptive advantage not only reduces the cost of corporate compliance, but also enables the enterprises to flexibly adapt to the changes of the international market so as to enhance the ability of enterprises to cope with crises and sustainable development in the international market(Wagner, 2011).At the same time, excellent sustainable development performance can also enhance an enterprise's opportunities for international financing, thereby being more conducive to expanding overseas markets.

However, while existing research generally acknowledges the positive role of sustainable development in corporate internationalization and touches upon the influence of green technology innovation, there remain notable shortcomings. Most of the current literature either examines green technology innovation and internationalization in isolation or oversimplifies sustainable development performance as a direct influencing factor, failing to systematically uncover the complete mediating pathway of “green technology innovation → sustainable development performance → corporate internationalization.” In particular, there is a lack of in-depth examination of the specific mediating role of sustainable development performance within this mechanism, as well as a failure to differentiate its varying effects on the breadth and depth of internationalization. Therefore, to address these research gaps, this paper, based on the logical chain of “green technology innovation—sustainable development performance—corporate internationalization level,” aims to thoroughly investigate the specific impact of green technology innovation on the breadth and depth of corporate internationalization, with a focus on examining the mediating role of sustainable development performance. Through this, the study seeks to reveal the underlying transmission mechanism, providing theoretical foundations and practical insights for enterprises to promote sustainable internationalization through green innovation.

## 3. Research Hypotheses

### 3.1. Green technology innovation and corporate internationalization

As a key driver of corporate sustainable development, green technology innovation primarily manifests in the internationalization process as an expansion of market coverage—that is, an enhancement of the breadth of internationalization.

Green technology innovation acts as a high-quality signal, helping firms overcome information asymmetry in international markets and rapidly establish external legitimacy(Xiao H J, Yang Z & Ling, 2022) When companies showcase their environmental responsibility and technological capabilities through vehicles such as green patents and environmental certifications, host-country governments, consumers, and supply chain partners can more effectively "identify" the firm's quality attributes, thereby lowering information barriers to market entry( Chen, Lai & Wen, 2006; Chiou et al., 2011). Particularly for firms from emerging markets, green technology innovation can effectively counteract the negative country-of-origin effect, altering the international clients' stereotype of "low quality and low price" associated with developing country firms (Hu, Zhou & Li, 2023). This signaling mechanism is especially crucial in imperfectly competitive market environments, as it provides a shortcut for firms to quickly build trust in unfamiliar markets (Danneels, 2002).

Faced with diverse global environmental regulatory systems, green technology innovation endows firms with institutional adaptability and compliance flexibility (Li Q Y & Xiao Z H, 2020). By developing technological solutions that comply with different environmental standards, firms can simultaneously meet the entry requirements of multiple heterogeneous markets, thereby achieving economies of scope. Empirical studies show that firms possessing a portfolio of green patents demonstrate stronger adaptive capabilities when dealing with differentiated environmental regulations (Qin et al. , 2021). Energy Star standards. Furthermore, green technology innovation helps firms access the global green supply chain network and acquire green complementary assets beyond traditional resources (Kusterer & Hussain, 2001; Koopman, Wang & Wei, 2014). These resources further fuel the firm's cross-market expansion. Therefore, this study proposes the hypothesis that:

H1a: Green technology innovation can significantly enhance the internationalization breadth of enterprises

Unlike market-scope expansion, the impact of green technology innovation on internationalization depth is chiefly reflected in the intensity of penetration and the degree of local embedding within markets that firms have already entered. In the process of deep-level international expansion, enterprises need to achieve a high degree of integration with the local institutional environment, and green technology innovation serves as a key pathway to obtaining this institutional legitimacy. Through green technology innovation, companies demonstrate their recognition of and commitment to the host country's environmental norms and social values, thereby winning the recognition and support of local governments, communities, and non-governmental organizations (Horbach, 2008). This legitimacy not only reduces regulatory pressure and political risks but also creates a more favorable operating environment for the enterprise. Furthermore, green technology innovation helps companies establish strong-tie networks with local stakeholders, including cooperation with environmental agencies, participation in local environmental governance projects, and building long-term relationships with green suppliers (Antoine & Glachant, 2012). These deep embedding behaviors further consolidate the enterprise's position in the local market, raise exit barriers, and ultimately enable sustainable deep-level internationalization. Green innovation also helps mitigate the negative environmental impacts of production activities, facilitates the establishment of a positive brand image, strengthens market legitimacy in international contexts, and enables firms to circumvent green trade barriers imposed by host countries (Cainelli & Montresor, 2011).For instance, BYD's success in overcoming green trade barriers between Europe and America through electric vehicle technology innovation exemplifies the direct impact of green technology innovation on the scope and depth of internationalization(Dunning, 1980;Qin et al., 2021). Therefore, this study proposes the hypothesis that:

H1b: Green technology innovation can significantly enhance the internationalization depth of enterprises.

### 3.2 The mediating role of sustainable development performance

Sustainable development performance plays a crucial role in the relationship between enterprises' green technological innovation and the breadth and depth of their internationalization. Existing studies have shown that green technological innovation enhances environmental performance, providing legitimacy endorsement and competitive advantages for enterprises' internationalization, thereby influencing the breadth (market coverage) and depth (market penetration degree) of internationalization (Sun, Sun & Dong, 2024). Outstanding environmental performance helps enterprises establish long-term and stable cooperative relationships with high-end partners in the global value chain and deeply participate in international division of labor. At the same time, environmental performance, as an important component of green dynamic capabilities, can transform external pressure into internal innovation, ultimately enhancing financial performance and providing continuous resources for the deep expansion of internationalization (Gao L, 2022). Enterprises need to achieve sustainable development through the synergy of economic, environmental, and social performance. Green technology innovation can affect the internationalization of enterprises through environmental and economic performance paths (Elkington, 1998). In the path of environmental performance, green technology can improve the environmental performance of enterprises and enhance the legitimacy recognition of enterprises in the international market by optimizing resource utilization efficiency and reducing pollution emissions (Zhang S F, Bu M L, 2011). In the economic performance path, by developing differentiated products, green technology can seize market opportunities and improve profit margins and revenue growth rates, and then provide financial support for enterprise internationalization (Chen et al, 2004). Therefore, this study proposes the hypothesis that:

H2a: Environmental performance plays a mediating role between green technology innovation and enterprise internationalization’s breadth;

H2b: Economic performance plays a mediating role between green technology innovation and enterprise internationalization’s depth.

H2c: Environmental performance plays a mediating role between green technology innovation and enterprise internationalization’s breadth;

H2d: Economic performance plays a mediating role between green technology innovation and enterprise internationalization’s depth.

### 3.3 The adjustment effect of internalization advantage

Green technological innovation enhances environmental compliance and resource efficiency, providing enterprises with a "green passport" for entering the international market. However, its actual impact on the breadth and depth of internationalization significantly depends on the internalization ability of enterprises to integrate resources. When enterprises possess strong internalization capabilities (such as mature supply chain management and a system for integrating technical knowledge), they can more effectively convert their green technology advantages into specific product or process innovations, reduce international market operation costs, and thereby support broader market coverage and deeper local penetration. The internalization advantage enables enterprises to absorb and transform the environmental regulations of the host country, through the localization of green technology research and development, to deepen market integration, and at the same time, to expand the market breadth through collaborative innovation networks. Enterprises with internalization advantages can more efficiently embed green technologies into the global supply chain and strengthen the internationalization effect of technological innovation, but internalization advantages may have some differential adjustments to the breadth and depth of internationalization. For the breadth of internationalization, the advantage of internalization requires

companies to concentrate resources on optimizing the technological adaptability of existing markets, which may inhibit the development of new markets. Through technological synergies and internalization advantages, the depth of internationalization can accelerate the localization of technology applications and deepen market penetration(Bergek et al, 2008). Therefore, this study proposes the hypothesis that:

H3a: The internalization advantage negatively regulates the relationship between green technology innovation and internationalization breadth;

H3b: The internalization advantage positively regulates the relationship between green technology innovation and internationalization depth.

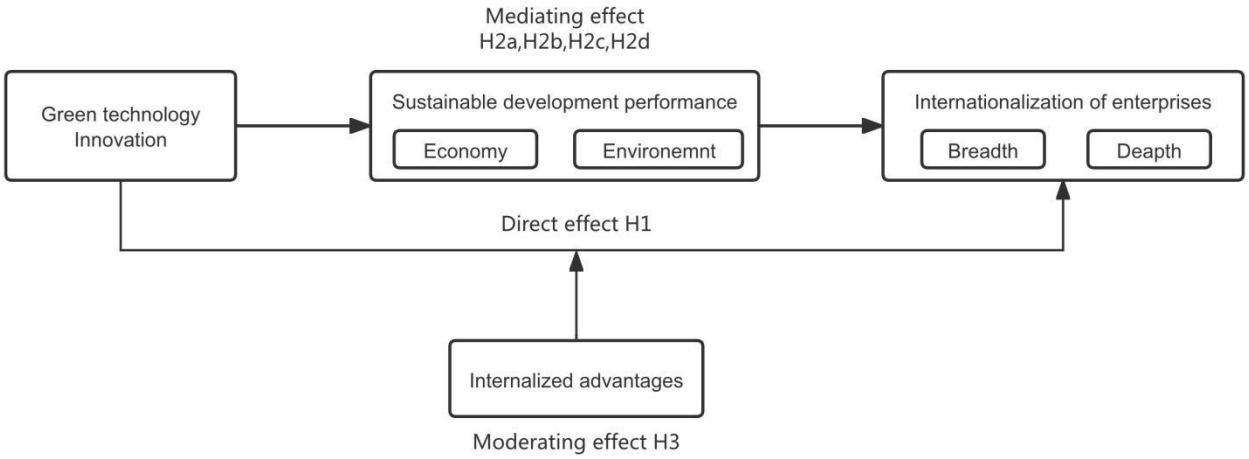


**Figure 1:** Concept Model

## 4. Methodology

### 4.1. Sample Selection

This study begins with the initial sample of A-share listed manufacturing companies from 2012 to 2022. To construct a balanced panel and ensure data integrity and reliability, we applied the following screening procedures: (1) Removing firms labeled as ST, *ST, or PT; (2) Dropping observations with missing for key variables. (3) To mitigate the influence of outliers, all continuous variables were winsorized at the 1st and 99th percentiles. Consequently, the final dataset used for regression analysis consists of 3,925 observations.

The data on corporate green patents are sourced from the Green Patent Research Database within the China Research Data Service Platform (CNRDS). This database identifies and labels the "green" attributes of patents based on the International Patent Classification Green Inventory published by the World Intellectual Property Organization (WIPO) and relevant classification standards issued by the China National Intellectual Property Administration (CNIPA). In this study, we employ the number of granted green patents (GPC) and the number of green patent applications (GPA) as the core measurement indicators for green technology innovation.

Data on the breadth and depth of corporate internationalization are obtained from the Overseas Direct Investment and Financial Statements sub-databases of the CSMAR Database. The proxy variables for sustainable development performance—environmental performance and economic performance—are derived from the corporate social responsibility rating reports published by Hexun.com, and have been standardized and log-transformed. The remaining control variables (such as firm size and asset-liability ratio) are collected from the CSMAR Database or manually compiled from corporate annual reports.

### 4.2. Variable Definitions

**Table 1.** Detailed Statistics of Variable Definitions and Measures

| Variable type | Variable | symbol | Measurement method |
|---|---|---|---|
| dependent variable | Internationalization breadth | lny2 | Add 1 to the number of overseas subsidiaries of the enterprise and take the natural logarithm |
| | Depth of Internationalization | Rev | Overseas business revenue of the enterprise (in billions of yuan) |
| independent variable | Number of green patent authorizations | GPC | The number of green patent authorizations obtained by the enterprise in that year |
| Intermediary variable | Environmental Performance | lnEnv | Hexun Network Environmental Responsibility Score (standardized and logarithmic) |
| | Economic performance | lnEcon | Logarithmic Return on Assets (ROA) |
| control variable | Enterprise size | lnSize | Take the natural logarithm of total assets |
| | Asset liability ratio | ALR | Total liabilities/total assets |
| | Key pollution monitoring | KeyPMU | Is the enterprise listed as a key pollution monitoring unit (1=Yes, 0=No) |
| | Pollutant emissions meet the standard | PEA | Does the enterprise meet the standard for pollutant emissions in the current year (1=Yes, 0=No) |
| | R&D investment | lnRD | Take the natural logarithm of total investment |

### 4.3 Model construction

(1) Benchmark regression model:

$$lny2_{it} = \alpha_0 + \alpha_1 GPC_{it} + \alpha_2 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$
$$Rev_{it} = \beta_0 + \beta_1 GPC_{it} + \beta_2 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$

Among them$\mu_i$, is the fixed effect of the enterprise, $\gamma_t$is the fixed effect of the year, and $Controls$ is the set of control variables.

(2) Mediation effect model:

Testing the effect of GPC on mediator variables (lnEnv, lnEcon):

$$lnEnv_{it} = \theta_0 + \theta_1 GPC_{it} + \theta_2 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$

Testing the impact of mediator variables on the dependent variable:

$$lny2_{it} = \lambda_0 + \lambda_1 lnEnv_{it} + \lambda_2 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$

After adding mediator variables, test the significance of GPC coefficients:

$$lny2_{it} = \delta_0 + \delta_1 GPC_{it} + \delta_2 lnEnv_{it} + \delta_3 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$

If $\delta_1$ it is significant and less than $\alpha_1$ in the baseline model, the mediating effect is established. Similarly, a mediation model for economic performance (lnEcon) can be constructed.

(3) Adjustment effect model:

Introduce the internalization advantage INTLAdv and use whether it has passed ISO9001 certification as a moderating variable to construct an interaction term:

$$Rev_{it} = \eta_0 + \eta_1 GPC_{it} + \eta_2 INTLAdv_{it} + \eta_3 (GPC \times INTLAdv)_{it} + \eta_4 Controls_{it} + \mu_i + \gamma_t + \epsilon_{it}$$

## 5. Results and discussions

### 5.1. Descriptive statistical analysis

The descriptive statistical results in Table 2 shows that the sample contains 3925 observations. The average value of internationalization depth (Rev) is 20.219, with a high standard deviation of 60.286, indicating significant differences in internationalization depth among enterprises. The average value of internationalization breadth (lny2) is 0.917, with a standard deviation of 0.895, indicating that the differences in the international market coverage of enterprises are relatively small. The average value of green patent authorization (GPC) is 7.75, with a maximum value of 40, reflecting the uneven investment of sample enterprises in green technology innovation. The standard deviations of environmental performance (lnEnv) and economic performance (lnEcon) are 0.219 and 1.465, respectively, indicating significant differences in both dimensions of sustainable development for enterprises.

**Table 2:** Descriptive Statistics

| variable | Variable Symbol | Sample size | average value | standard deviation | minimum value | Maximum value |
|---|---|---|---|---|---|---|
| Depth of Internationalization | Rev | 3925 | 20.219 | 60.286 | -3.136 | 1261.007 |
| Internationalization breadth | lnSub | 3925 | 0.917 | 0.895 | 0.000 | 4.718 |
| Number of green patent authorizations | GPC | 3925 | 7.750 | 10.305 | 1.000 | 40.000 |
| Environmental Performance | lnEnv | 3925 | 0.078 | 0.219 | 0.000 | 0.693 |
| Economic performance | lnEcon | 3925 | 22.154 | 1.465 | 15.933 | 26.894 |
| ISO9001 certification | INTLAdv | 3925 | 0.357 | 0.479 | 0 | 1 |
| Key pollution monitoring | KeyPMU | 3925 | 0.327 | 0.469 | 0.000 | 1.000 |
| Pollutant emissions meet the standard | PEA | 3925 | 0.998 | 0.039 | 0.000 | 1.000 |
| R&D investment | lnRD | 3925 | 18.858 | 1.353 | 12.206 | 23.571 |
| Enterprise size | lnSize | 3925 | 3.117 | 0.052 | 3.036 | 3.218 |
| Asset liability ratio | ALR | 3925 | 0.439 | 0.173 | 0.136 | 0.726 |

The mean of the adjusted variable ISO9001 certification (INTLAdv) is 0.357, with a standard deviation of 0.479, indicating that approximately 35.7% of the companies in the sample have obtained ISO9001 certification, and there are significant differences in the distribution of this certification among companies. At the same time, the mean of pollutant emission compliance (PEA) is close to 1 (0.998), while the standard deviation is only 0.039, indicating that the vast majority of enterprises can meet the pollutant emission standards, reflecting the overall

environmental compliance of the industry. The average value of the natural logarithm of R&D investment (lnRD) is 18.858, with a standard deviation of 1.353, a minimum value of 12.206, and a maximum value of 23.571, indicating that there are certain differences in R&D investment among the sample companies. The standard deviation of enterprise size (lnSize) is relatively small, indicating that the sample enterprise size is relatively balanced, while the average asset liability ratio (ALR) is 0.439, which is at a relatively healthy level.

### 5.2 Correlation analysis

The correlation analysis in Table 3 reveals significant correlation between variables. The correlation coefficient between internationalization depth (Rev) and internationalization breadth (lnSub) is 0.300 ($p<0.01$), indicating that a company's coverage in the international market is positively correlated with its degree of internationalization, meaning that companies with wider international market expansion tend to invest deeper in international business. In addition, the correlation coefficient between Rev and Green Patent Grant Volume (GPC) is 0.333 ($p<0.01$), indicating that companies with higher levels of internationalization tend to have more green innovation capabilities. This may be because international enterprises face stricter environmental regulations and market competition, which promotes innovation in green technologies. In terms of environmental performance and pollutant emission compliance (PEA), it shows that PEA has a low correlation with most variables. For example, the correlation coefficient between PEA and internationalization depth (Rev) is only 0.00815 and not significant, indicating that the degree of internationalization of a company has a relatively small impact on its pollutant emission compliance. R&D investment (lnRD) is significantly positively correlated with internationalization depth (Rev) and internationalization breadth (lnSub), with correlation coefficients of 0.427 and 0.388, respectively ($p<0.01$). This indicates that companies with higher levels of internationalization invest more in research and development, possibly due to more intense competition in the international market, which drives companies to improve their technological capabilities to maintain a competitive advantage. At the same time, there is a strong positive correlation between lnRD and enterprise size (lnSize) ($r=0.511$, $p<0.01$), reflecting that larger enterprises usually have stronger R&D capabilities. The asset liability ratio (ALR) shows strong correlation with multiple variables, especially with internationalization breadth (lnSub) ($r=0419$, $p<0.01$) and internationalization depth (Rev) ($r=0.453$, $p<0.01$). This indicates that companies with higher debt ratios often invest more funds in research and development and international expansion, possibly because these companies are more inclined to support their growth strategies through financing. However, the correlation between ALR and environmental performance (PEA) is extremely low ($r=-0.00124$), indicating that a company's capital structure has a relatively small impact on environmental compliance.

**Table 3:** Correlation Analysis

| variable | Rev | lnSub | GPC | KPM | PEA | lnRD | lnSize | ALR |
|---|---|---|---|---|---|---|---|---|
| Rev | 1 | | | | | | | |
| lnSub | 0.300*** | 1 | | | | | | |
| GPC | 0.333*** | 0.180*** | 1 | | | | | |
| KeyPMU | 0.136*** | 0.0950*** | 0.00117 | 1 | | | | |
| PEA | 0.008 | -0.017 | 0.001 | -0.014 | 1 | | | |
| lnRD | 0.427*** | 0.388*** | 0.225*** | 0.339*** | 0.012 | 1 | | |
| lnSize | 0.212*** | 0.195*** | 0.152*** | 0.136*** | -0.001 | 0.511*** | 1 | |
| ALR | 0.453*** | 0.419*** | 0.295*** | 0.235*** | -0.001 | 0.797*** | 0.360*** | 1 |

Note:* p < 0.1, ** p < 0.05, ***, p < 0.01

### 5.3 Benchmark regression

The benchmark regression results (Table 4) show that the green patent authorization quantity (GPC) has a significant positive impact on both the breadth and depth of enterprise internationalization. Specifically, the regression coefficient of GPC for the breadth of internationalization is 0.0054 ($p<0.05$), and the regression coefficient for the depth of internationalization is 0.8138 ($p<0.1$), which supports the core hypothesis of "green technology innovation promotes enterprise internationalization" and indicates that investment in green innovation by enterprises may enhance their international competitiveness. In terms of controlling variables, the impact of firm size (lnSize) on the breadth and depth of internationalization is not significant (coefficients of 0.2258 and -6.8971, respectively), which may reflect that firm size itself is not a decisive factor in promoting internationalization, but is more influenced by factors such as firm strategy and industry characteristics. Research and development investment (lnRD) has a significant positive impact on internationalization breadth (6.2259, $p<0.01$), but its impact on internationalization depth is not significant (-67.3890, $p>0.1$). This result indicates that R&D investment mainly promotes the breadth expansion of enterprises in the international market, but may not necessarily enhance their penetration ability in the international market. The compliance with pollutant emission standards (PEA) has a significant negative impact on the breadth of internationalization (-0.2537, $p<0.01$), indicating that environmental compliance costs may pose certain constraints on the internationalization expansion of enterprises. The asset liability ratio (ALR) has a significant positive impact on internationalization depth (9.8127, $p<0.05$), which may indicate that moderate financial leverage can help companies expand more deeply into international markets.

**Table 4:** Benchmark Regression Analysis

| variable | Benchmark regression test | |
|---|---|---|
| | Internationalization breadth | Depth of Internationalization |
| GPC | 0.0054** | 0.8138* |
| | (2.10) | (1.79) |
| KeyPMU | 0.0099 | 1.1841 |
| | (0.31) | (0.54) |
| PEA | -0.2537*** | 3.1595 |
| | (-2.61) | (0.79) |
| lnRD | 6.2259*** | -67.3890 |
| | (4.11) | (-0.35) |
| lnSize | 0.2258 | -6.8971 |
| | (1.49) | (-0.72) |
| ALR | -0.0196 | 9.8127** |
| | (-0.67) | (2.24) |
| _cons | -18.0151*** | 38.6099 |
| | (-3.96) | (0.07) |
| Fixed effects of enterprises | yes | yes |
| Fixed year effect | yes | yes |
| N | 3687 | 3686 |
| R2 | 0.830 | 0.646 |

Note:* p < 0.1, ** p < 0.05, ***, p < 0.01

The significant impact of green patents on both the breadth and depth of internationalization reveals that green technology possesses dual attributes as both an "institutional passport" and a "competitive moat." On one hand, green patents help firms overcome latent institutional barriers by reducing compliance costs associated with host-country environmental regulations (as reflected in the negative coefficient of PEA), thereby expanding market coverage. On the other hand, the premium from differentiated products or processes enabled by green technology supports firms in deepening localization and increasing market share in already-entered markets.

The non-significance of firm size suggests that, against the backdrop of green transformation and the knowledge economy, traditional advantages derived from scale—such as decreasing marginal costs and bargaining power—have been superseded by the institutional compliance and competitive edge afforded by green technology innovation. Small and medium-sized enterprises (SMEs) can potentially bypass the classical path of "first grow large, then go global," and directly adopt internationalization models characterized by "small yet deep" or "small yet broad" market engagement.

### 5.4 Mediation effect test

The results of the mediation effect test reveal the path through which green technology innovation affects the internationalization of enterprises through environmental and economic performance(Tabble 5). Firstly, the green patent authorization quantity (GPC) has a significant positive impact on both environmental and economic performance (coefficients of 0.0022 and 0.0026, respectively), indicating that green technology innovation can simultaneously enhance the environmental and economic performance of enterprises. Secondly, the impact of environmental and economic performance on internationalization is significantly positive, which verifies their mediating role. Specifically, the impact coefficients of economic performance on the breadth and depth of internationalization are 0.1106 and 12.0054, respectively, while the impact coefficients of environmental performance are 0.1115 and 35.2851, both significant at the 1% level. This result supports the triple bottom line theory, which suggests that companies achieve sustainable development by balancing environmental, economic, and social benefits. The influence of control variables is basically consistent with the baseline regression, further ensuring the reliability of the research results.

Although the direct effects of GPC on economic and environmental performance are similar (0.0026 vs. 0.0022), their mediated intensities on internationalization depth diverge sharply: the coefficient for environmental performance (35.29) is nearly three times that for economic performance (12.01). This indicates that environmental improvements brought by green technologies are more easily "noticed" by host-country governments, consumers and supply-chain partners, thereby lowering the local-embedding costs required for deep expansion. In other words, environmental performance possesses a stronger signaling-leverage function in the depth dimension, helping firms overcome institutional barriers and obtain a "fast-pass" for deep expansion.

### 5.5 Moderation effect test

The regulating variable in Table 6 is whether it has passed ISO9001 certification. Explored the moderating role of INTLAdv certification in the relationship between green technology innovation and enterprise internationalization. The results showed that the interaction term GPC * INTLAdv had a significant negative impact on internationalization breadth (-0.0005), while its impact on internationalization depth was significant positive (0.1438). This differentiated impact indicates that internalization advantage will weaken the promoting effect of green technology innovation on market coverage, but will strengthen its driving effect on market penetration. This may be because companies with internalization advantage tend to delve deeper into the markets they have already entered, rather than continuing to expand their market scope.

**Table 5:** Data statistics of mediation effect test

| variable | (1) Environmental Performance | (2) Internationalization breadth | (3) Depth of Internationalization | (4) Economic performance | (5) Internationalization breadth | (6) Depth of Internationalization |
|---|---|---|---|---|---|---|
| GPC | 0.0022*** | 0.0029** | 0.9474*** | 0.0026** | 0.0055*** | 0.4190*** |
| | (3.90) | (2.05) | (7.65) | (1.97) | (4.03) | (3.60) |
| lnEcon | | 0.1106* | 12.0054*** | | | |
| | | (1.72) | (3.02) | | | |
| lnEnv | | | | | 0.1115*** | 35.2851*** |
| | | | | | (3.34) | (16.37) |
| KeyPMU | -0.0200* | -0.1054*** | 0.1689 | -0.0334* | 0.0180 | -2.2165 |
| | (-1.91) | (-3.24) | (0.07) | (-1.77) | (0.73) | (-0.84) |
| PEA | -0.0548 | -0.4651 | 3.0434 | -0.0393 | -0.1589 | -3.4529 |
| | (-0.65) | (-1.41) | (0.17) | (-0.71) | (-0.73) | (-0.12) |
| lnTA | -1.5353*** | 5.1647*** | -49.8606 | 14.8727*** | 4.3631*** | -459.0292*** |
| | (-5.23) | (9.87) | (-0.82) | (16.87) | (4.78) | (-7.48) |
| DAR | -0.1525*** | 0.0160 | -5.1521 | 0.4257*** | 0.1757 | -11.4560 |
| | (-3.49) | (0.18) | (-0.57) | (4.10) | (1.56) | (-1.56) |
| lnRD | -0.0022 | 0.1271*** | 9.8375*** | 0.2275*** | -0.0507** | 8.2657*** |
| | (-0.26) | (7.03) | (5.56) | (6.99) | (-2.26) | (5.29) |
| _cons | 5.0470*** | -17.1615*** | -18.9962 | -28.7311*** | -14.5152*** | 577.7234*** |
| | (5.99) | (-12.25) | (-0.11) | (-11.89) | (-6.07) | (3.84) |
| Fixed effects of enterprises | yes | yes | yes | yes | yes | yes |
| Fixed year effect | yes | yes | yes | yes | yes | yes |
| N | 3701 | 3700 | 3701 | 3700 | 3701 | 3700 |
| R2 | 0.830 | 0.616 | 0.830 | 0.619 | 0.830 | 0.616 |

Note: * p < 0.1, ** p < 0.05, ***, p < 0.01

This nuanced moderating role offers rich theoretical implications. First, it extends the classic internalization theory by revealing that the advantage of established systems (e.g., ISO 9001) is not a universal amplifier for all types of international expansion driven by green innovation. Instead, it acts as a strategic filter, channeling resources towards activities that best leverage existing organizational routines and knowledge-integration capabilities. Deepening market penetration in familiar territories aligns with the exploitation of existing internalization advantages, allowing firms to extract maximum rents from their green technologies. In contrast, broadening into new markets represents an exploration activity, which requires building new legitimacy and adapting systems from scratch—a process where existing internalization advantages may even become a source of rigidity or "competency trap," temporarily slowing expansion breadth.

Second, this finding aligns with the attention-based view of the firm. Management teams in firms with mature internalization systems likely have fixed attention and resource budgets. Faced with the opportunity to deploy new green technologies, they rationally prioritize applying them to deepen positions in markets where their

systems are already recognized and effective (leveraging synergies), rather than diluting efforts across unfamiliar, high-uncertainty markets. This strategic choice highlights a contingency perspective: the value of an internalization advantage is contingent on the strategic goal (depth vs. breadth) of the internationalization activity.

**Table 6:** Data statistics for moderating effect tests

| | (1)<br>Internationalization breadth | (2)<br>Depth of Internationalization |
|---|---|---|
| GPC | 0.0056*** | 0.7287*** |
| | (4.63) | (6.13) |
| INTLAdv | 0.0270 | 4.7930** |
| | (1.34) | (2.41) |
| GPC*INTLAdv | -0.0005** | 0.1328*** |
| | (-1.99) | (5.53) |
| KeyPMU | 0.0108 | 0.7916 |
| | (0.50) | (0.37) |
| PEA | -0.2535 | 3.1262 |
| | (-1.48) | (0.18) |
| lnTA | 6.1662*** | -62.3344 |
| | (10.20) | (-1.04) |
| DAR | 0.2246** | -6.1126 |
| | (2.49) | (-0.68) |
| lnRD | -0.0189 | 9.6188*** |
| | (-1.06) | (5.47) |
| _cons | -17.8516*** | 24.6859 |
| | (-10.29) | (0.14) |
| Fixed effects of enterprises | yes | yes |
| Fixed year effect | yes | yes |
| N | 3701 | 3700 |
| R2 | 0.830 | 0.616 |

Note:* p < 0.1, ** p < 0.05, ***, p < 0.01

### 5.6 Mechanism of Green Innovation's Impact on Enterprise Internationalization

The preceding empirical analysis has confirmed the direct impact of green technology innovation on the breadth and depth of corporate internationalization, the mediating role of sustainable development performance, and the moderating effect of internalization advantages. Integrating these findings will facilitate an in-depth examination of the specific mechanisms through which green innovation drives internationalization, clarifying the internal logic of how green innovation influences corporate internationalization.

#### 5.6.1 The Dual Attributes of "Institutional Passport" and "Competitive Moat"

The baseline regression results indicate that green patents (GPC) can simultaneously drive both the breadth (lny2) and depth (Rev) of internationalization. This validates the dual attributes of green technology highlighted in the earlier hypotheses (H1a, H1b) and analysis.

Expanding Market Breadth as an "Institutional Passport": As a high-quality signal, green patents directly help enterprises overcome information asymmetry in overseas markets and rapidly establish external legitimacy. This reduces the information and cognitive barriers to entering new markets, enabling companies to enter more

countries or regions at a lower initial cost, thereby effectively promoting the expansion of internationalization breadth.

Deepening Market Penetration as a "Competitive Moat": The technological advantage represented by green patents directly constitutes differentiated product competitiveness. This allows enterprises in markets they have already entered to better meet local demand for eco-friendly products and circumvent green trade barriers, thereby increasing market share and operational embeddedness—that is, deepening the degree of internationalization.

### 5.6.2 Parallel Pathways of Environmental Legitimacy and Economic Resources

The mediation effect tests verified the dual-path mediating role of sustainable performance (H2a–H2d). The underlying mechanisms are as follows:

The "Legitimacy-Granting" Mechanism of Environmental Performance: Green innovation first improves environmental performance (lnEnv). As the results show, this improvement contributes far more to the depth of internationalization than to its breadth. This profoundly reveals that when deeply embedded in a host country, environmental legitimacy becomes critical social capital. Superior environmental performance is not merely passive compliance with regulations but an active pathway to gaining the trust and recognition of local governments, communities, and value-chain partners. This trust can significantly reduce political risks, community resistance, and partner skepticism during deep operations, thereby paving the way for long-term cultivation in the local market. The "Resource Provision" Mechanism of Economic Performance: Green innovation also enhances economic performance (lnEcon). Improved profitability (ROA) provides direct financial resource support for internationalization activities. Whether for the upfront investment required for breadth expansion or the sustained localization investments in R&D and marketing needed for depth penetration, a solid financial foundation is indispensable. This mechanism emphasizes that green innovation must ultimately achieve economic returns through the market to continuously "fuel" the implementation of internationalization strategies.

### 5.6.3 Strategic Focus and Path Dependence under Internalization Advantages

The moderation effect analysis reveals that internalization advantages (INTLAdv) exert a directional differential impact on the relationship between green innovation and internationalization (H3a–H3b). The underlying mechanism pertains to the logic of strategic resource allocation within firms.

The "Capability Synergy" Mechanism for Depth Promotion: Internalization advantages positively moderate the relationship between green innovation and internationalization depth. This is because mature internalized management systems can integrate the outcomes of green technology innovation more efficiently and reliably into the firm's global operations. This "technology-management" synergy amplifies the value of green innovation, making it easier to achieve technological localization, quality stability, and process optimization in already familiar markets, thereby strengthening market penetration and customer lock-in effects. This reflects the strategic choice of firms to "deeply cultivate" entered markets by leveraging existing organizational capabilities. The "Attention Constraint" Mechanism for Breadth Suppression: Internalization advantages negatively moderate the relationship between green innovation and internationalization breadth. Establishing and maintaining a set of internalization advantages itself consumes significant managerial attention and resources. When a firm acquires new green innovation outcomes, management, driven by bounded rationality, tends to apply them to areas that maximize the synergistic effects of existing systems and ensure more certain returns—namely, already entered markets—rather than exploring entirely new markets that require rebuilding management adaptation and face high uncertainty. This moderating effect is essentially a form of strategic focus under resource and attention constraints, which may lead to prioritizing depth over breadth in the short term.

## 5.7 Results Verification

### 5.7.1 Robustness test

The robustness tests (Table7 and Table 8) further validated the robustness of the baseline regression results. Green Patent Application Volume (GPA) was used as the explanatory variable instead of Green Patent Grant Volume (GPC). The results showed that the regression coefficients of GPA on internationalization breadth and depth were 0.0024 ($p<0.05$) and 0.2631 ($p<0.01$), respectively, both of which were significantly positive, further verifying the positive promoting effect of green innovation on enterprise internationalization. This result is consistent with the findings in the benchmark regression, indicating that green innovation has a relatively stable driving effect on the internationalization strategy of enterprises. Furthermore, considering the existence of the "Sleeping Beauty phenomenon" in patent authorization, a lagged two period model test is further adopted in Table 5-8 to control for possible endogeneity issues and robustness verification. The results showed that the positive impact of GPA on internationalization breadth (0.0035, $p<0.05$) was still significant, and the positive impact on internationalization depth (0.2044, $p<0.1$) reached a significant level in the robustness test. This result further proves that green innovation has strong stability and reliability in promoting the internationalization of enterprises.

**Table 7:** Data statistics for robustness tests 1

| variable | Robust Test | |
|---|---|---|
| | Internationalization breadth | Depth of Internationalization |
| GPA | 0.0024** | 0.2631*** |
| | (2.43) | (3.04) |
| KeyPMU | 0.0117 | 1.2995 |
| | (0.37) | (0.56) |
| PEA | -0.2422*** | 4.9078 |
| | (-2.65) | (1.61) |
| lnRD | 6.4457*** | -32.7140 |
| | (4.35) | (-0.21) |
| lnSize | 0.2298 | -8.6861 |
| | (1.54) | (-0.91) |
| ALR | -0.0160 | 8.8111** |
| | (-0.57) | (2.30) |
| _cons | -18.7522*** | -51.1774 |
| | (-4.22) | (-0.11) |
| Fixed effects of enterprises | yes | yes |
| Fixed year effect | yes | yes |
| N | 3701 | 3700 |
| R2 | 0.829 | 0.698 |

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

It is worth noting that all models have high $R^2$ ($R^2$=0.830 for benchmark regression internationalization breadth and 0.646 for internationalization depth; $R^2$=0.829 for robustness test 1, and 0.698 for internationalization depth), indicating that the models have good explanatory power. Therefore, the results of this study are statistically reliable and provide strong empirical support for promoting the internationalization of enterprises through green technology innovation.

**Table 8:** Data statistics for robustness tests 2

| variable | Robust Test | |
|---|---|---|
| | Internationalization breadth | Depth of Internationalization |
| GPA | 0.0035** | 0.2044* |
| | (2.16) | (1.94) |
| KeyPMU | -0.0246 | 2.3754 |
| | (-0.87) | (0.68) |
| PEA | -0.2811 | 6.1355 |
| | (-1.37) | (0.24) |
| lnRD | 7.1169*** | -65.0661 |
| | (8.46) | (-0.63) |
| lnSize | 0.1175 | -12.9731 |
| | (0.95) | (-0.85) |
| ALR | -0.0161 | 16.5652*** |
| | (-0.64) | (5.31) |
| _cons | -20.7491*** | -89.1359 |
| | (-8.72) | (-0.30) |
| Fixed effects of enterprises | yes | yes |
| Fixed year effect | yes | yes |
| N | 1914 | 1913 |
| R2 | 0.871 | 0.692 |

Note: * p < 0.1, ** p < 0.05, ***, p < 0.01

### 5.7.2 Heterogeneity test

The analysis of property rights differences in Table 9 reveals significant differences in the impact of green technology innovation on internationalization between state-owned and non-state-owned enterprises. For the breadth of internationalization, the green patent authorization (GPC) of non-state-owned enterprises shows a significant positive impact (coefficient 0.0061, p<0.01), while state-owned enterprises, although having the same coefficient, do not have statistical significance. In terms of internationalization depth, the influence of non-state-owned enterprises is more prominent (coefficient 1.3099, p<0.01), far higher than that of state-owned enterprises (coefficient 0.5183, not significant). This does not simply indicate which is superior, but reveals a fundamental difference in the strategic logic and constraints under which firms with different ownership structures leverage green innovation.

For Non-State-Owned Enterprises, green patents serve as a key strategic tool to overcome their "liability of legitimacy" and "resource constraints". Being more sensitive to market signals, they can more rapidly translate green technology innovation into products or compliance solutions that meet the needs of specific overseas markets. Therefore, the strategic implication is to deeply integrate green innovation into an agile market development strategy. By leveraging their institutional flexibility, they should target niche or emerging markets that are sensitive to green standards but not yet dominated by giants, achieving rapid market entry and penetration.

For State-Owned Enterprises, their internationalization is often tied to national strategy, resource acquisition, and scale advantages. The insignificant role of green innovation in promoting their internationalization may stem from the multiplicity of their strategic objectives, path dependence on traditional scale and resource advantages, and more complex decision-making processes when facing international environmental regulations. The strategic implication for them is to clearly prioritize green innovation in top-level strategic design. They need to transform their green technological advantage from a "compliance cost" into the "core value proposition" for leading major overseas projects (e.g., green infrastructure under the Belt and Road Initiative). Furthermore, they should leverage

their scale and strength to position themselves as integrators and shapers of global green supply chains or industry standards.

**Table 9:** Property Rights Nature (State owned/non-state-owned)

| variable | Internationalization breadth | | Depth of Internationalization | |
|---|---|---|---|---|
| | state owned enterprise | Non-state-owned enterprises | state owned enterprise | Non-state-owned enterprises |
| GPC | 0.0061 | 0.0061*** | 0.5183 | 1.3099*** |
| | (1.49) | (4.15) | (0.76) | (8.47) |
| KeyPMU | -0.0687 | 0.0716*** | -5.2224 | 2.4952 |
| | (-1.32) | (2.60) | (-1.29) | (0.85) |
| PEA | -0.0403 | -0.3170 | -7.8439* | 3.3826 |
| | (-0.63) | (-1.47) | (-1.86) | (0.15) |
| lnTA | 9.0031*** | 5.8999*** | 25.4545 | -244.2956 |
| | (4.36) | (3.05) | (0.21) | (-0.89) |
| DAR | 0.0152 | 0.2555 | -41.6229* | -0.3654 |
| | (0.06) | (1.35) | (-1.70) | (-0.02) |
| lnRD | -0.0209 | -0.0230 | 14.6827 | 7.1725 |
| | (-0.51) | (-0.46) | (1.49) | (0.92) |
| _cons | -26.5885*** | -16.9333*** | -317.6793 | 629.6482 |
| | (-4.38) | (-3.01) | (-1.06) | (0.78) |
| Fixed effects of enterprises | yes | yes | yes | yes |
| Fixed year effect | yes | yes | yes | yes |
| N | 1043 | 2495 | 1043 | 2494 |
| R2 | 0.839 | 0.839 | 0.582 | 0.614 |

Note:* p < 0.1, ** p < 0.05, ***, p < 0.01

The industry heterogeneity analysis in Table 10 reveals that green technology innovation has a significantly positive impact on the internationalization (particularly the depth) of firms in capital-intensive(0.7194, p<0.01) and technology-intensive industries(1.0466**, p<0.01), while it even inhibits the breadth expansion of firms in labor-intensive industries (-0.0337, p<0.01).

For capital-intensive and technology-intensive industries, green innovation is the core for building high-order competitive advantages. These industries are characterized by high R&D investment, long value chains, and stringent compliance requirements. Green technology innovation not only helps them meet global standards but can also, through the "innovation compensation effect," give rise to new materials, processes, or energy-efficiency solutions, thereby allowing them to gain technology premiums and the favor of high-end partners in overseas markets. The strategic implication is to strive to establish green technology as a source of industry entry barriers and pricing power, solidifying technological advantage into a lasting market position by deeply participating in or even leading the formulation of international green standards.

For labor-intensive industries, green innovation may, in the short term, increase costs and weaken their traditional cost advantage, posing a challenge to their breadth expansion. This indicates that a simple "green transition" may be insufficient to support their internationalization. The strategic implication lies in the necessity to closely integrate green innovation with a strategy for value chain upgrading. Firms should not merely focus on end-of-pipe treatment but should drive product transformation towards "green differentiation" through green design, application of eco-friendly materials, and circular economy models. This enables them to break away from the red ocean of low-cost competition and explore new market segments (e.g., sustainable fashion, eco-conscious consumer goods) where willingness to pay for sustainability exists.

**Table 10:** Industry heterogeneity test

| | Internationalization breadth | | | Depth of Internationalization | | |
|---|---|---|---|---|---|---|
| | labor-intensive | capital-intensive | technology-intensive | labor-intensive | capital-intensive | technology-intensive |
| GPC | -0.0336*** | 0.0101** | 0.0051* | 0.5267** | 1.0466** | 0.7194** |
| | (-3.03) | (2.37) | (1.74) | (1.34) | (1.13) | (1.42) |
| KeyPMU | -0.1928 | 0.0510 | 0.0138 | -3.0826 | -5.6734 | 3.6809 |
| | (-1.54) | (1.08) | (0.31) | (-0.88) | (-1.26) | (1.33) |
| PEA | 0.0000 | -0.4995*** | -0.1061 | 0.0000 | 21.2999*** | 3.1600* |
| | (.) | (-7.86) | (-1.49) | (.) | (6.75) | (1.85) |
| lnTA | 6.2829 | 9.0031*** | 5.8999*** | 25.4545 | -244.2956 | -83.2276 |
| | (1.40) | (4.36) | (3.05) | (0.21) | (-0.89) | (-0.30) |
| DAR | 1.3722** | 0.0152 | 0.2555 | -41.6229* | -0.3654 | -11.3439 |
| | (2.59) | (0.06) | (1.35) | (-1.70) | (-0.02) | (-0.99) |
| lnRD | 0.0096 | -0.0209 | -0.0230 | 14.6827 | 7.1725 | 14.0581* |
| | (0.08) | (-0.51) | (-0.46) | (1.49) | (0.92) | (1.96) |
| _cons | -19.1764 | -26.5885*** | -16.9333*** | -317.6793 | 629.6482 | 8.4670 |
| | (-1.39) | (-4.38) | (-3.01) | (-1.06) | (0.78) | (0.01) |
| Fixed effects of enterprises | yes | yes | yes | yes | yes | yes |
| Fixed year effect | yes | yes | yes | yes | yes | yes |
| N | 138 | 915 | 2643 | 138 | 915 | 2643 |
| R2 | 0.874 | 0.851 | 0.822 | 0.874 | 0.851 | 0.822 |

Note:* p < 0.1, ** p < 0.05, ***p < 0.01

## 6. Conclusions and Implications

### 6.1 Research Conclusion

This paper explores "The Effect of Green Technology Innovation on Enterprise Internationalization: Mediated by Sustainable Development Performance." This paper comprehensively explores the effect of green technology innovation of enterprise internationalization through sustainable development performance by combining theoretical and empirical analysis and the moderating role of internalization advantages. The main conclusions of this paper are summarized as follows:

(1) Green technology innovation substantially enhances the globalization of organizations.

The benchmark regression results demonstrate that the number of green patent authorizations (GPC) positively improves both internationalization's breadth and depth, supporting the main argument that green technology innovation promotes firm internationalization. This implies the role of Greentech innovation for organizations in circumventing environmental hurdles in the international arena alongside in heightening global competitiveness through the technology advantage.

(2) Sustainable development performance mediates the relationship between green technology innovation and firm internationalization.

The results of test for mediatory effect reveal that green technology innovation has indirect effects to the internationalization of firms by improving the economic and environmental performance. The magnitude of the impact coefficients on the breadth and depth of the internationalization from environmental and economical performance are, respectively, significantly positive, supporting the theory of triple bottom line for corporations, which achieves a sustainable development by integrating environmental, economic and social benefits.

(3) The internalization advantage serves a regulatory function in the correlation between green technology innovation and enterprise internationalization.

The results of moderation effect analysis suggest that internalization advantage (validated by ISO9001) moderates the relationship between green technology innovation and firm internationalization. Internalization advantage would reduce the positive impact of green technology innovation on market coverage whereas would intensify its effects on market penetration.This indicates that firms enjoy international advantage are inclined to “dig deeper” in current markets rather than enter into new markets.

### 6.2 Implications

This study not only extends the theoretical boundaries of the Resource-Based View but also offers critical practical insights for managers to leverage green patents in navigating institutional complexities.

(1)Green technology innovation should be regarded as a "strategic passport" for enterprises to break through international trade barriers and expand into overseas markets. While traditional internationalization theories emphasize the resource-based view and institutional distance, this study reveals that green technology itself constitutes a form of "institutional arbitrage" mechanism, which can be transformed into a competitive advantage in cross-border markets with significant differences in environmental regulations. This extends the applicability of the Resource-Based View (RBV) in green contexts, suggesting that future research could incorporate green technology into a dynamic framework of institutional legitimacy construction.

For managers, when formulating internationalization roadmaps, enterprises should prioritize the layout of green patents and proactively align with the environmental access standards of target markets through "green patent portfolios," thereby reducing the sunk costs and delayed entry risks caused by institutional distance.

The government should act as an "institutional bridge" for corporate green internationalization. Research indicates that green technology serves as a "passport" across international environmental regulations. Therefore, policies should focus on reducing the global cost of using this "passport." The government should lead efforts to promote mutual recognition of international green standards and fast-track review of green patents, and establish a service platform to systematically publish environmental access and compliance information for key markets. This would make institutional barriers visible and help companies transform their technological advantages into market access capabilities.

(2)The "dual mediation" pathway of sustainable development performance indicates that the value realization of green technology innovation relies on an economic-environmental synergy, rather than on one-dimensional ecological benefits alone. This study provides micro-evidence for the causal chain within the Triple Bottom Line (TBL) theory, revealing that economic performance and environmental performance are not merely parallel but exhibit a sequential complementary effect—environmental performance feeds back into economic performance by reducing externality costs, which in turn jointly drives internationalization. This finding addresses the limitation of prior research that often examined the three dimensions of sustainability in isolation, supporting a shift of the TBL from a normative framework toward a testable dynamic mediation model.

For managers, it is essential to establish a "green ROI" assessment framework that quantifies the marginal contribution of environmental performance improvements to economic outcomes, thereby avoiding mere

"greenwashing" investments. Furthermore, in planning their international expansion, firms could prioritize entering markets with high sensitivity to environmental premiums and strong consumer willingness to pay, in order to shorten the payback period for economic performance.

The government needs to focus on clearing the "performance transformation" pathway for green innovation. Green technology drives internationalization by enhancing both environmental and economic performance, which requires policies to simultaneously promote the market realization of environmental value and the sustainable acquisition of economic benefits. Specifically, the government can shape the market by increasing the proportion of green procurement and implementing green labeling, while also providing long-term financial support through the development of green finance, thereby preventing companies from falling into the dilemma of "high investment with low returns."

(3) This finding enriches the contingency perspective of internalization theory in the context of sustainability, indicating that internalization advantages do not unconditionally amplify the positive effects of green innovation. Instead, they reshape the boundaries of internationalization by altering resource allocation preferences (deep cultivation vs. broad expansion). This provides an empirical basis for introducing the concept of a "green internalization threshold" in future research—suggesting that once a firm's stock of green technology surpasses a critical level, internalization advantages may shift its strategy from breadth-oriented expansion to depth-oriented value capture.

For managers, firms with management system certifications such as ISO 9001 should guard against the "competency trap"—over-reliance on existing internalization advantages may lock the market scope of green technologies into narrow applications. In practice, establishing mechanisms for "outward licensing of green technologies" (e.g., patent licensing, green technology exports) can proactively break path dependency and achieve a dynamic balance between depth and breadth.

The government should incorporate "management capabilities" into the scope of policy support. Research finds that a firm's internalization advantages (organizational management capabilities) are key to moderating the internationalization effects of green innovation. This implies a gap in traditional support policies focusing solely on "technology" and "markets." Policies should support the development and promotion of "Green Internationalization" best-practice toolkits and training courses, systematically addressing deficiencies in global operational management capabilities, thereby maximizing the international strategic effectiveness of green technologies.

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**Reference**

Antoine D, Glachant M .Does Foreign Environmental Policy Influence Domestic Innovation? Evidence from the Wind Industry[J].Environmental and Resource Economics, 2012, 58(3):391-413

Bergek A, Jacobsson S, Carlsson B, et al. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis [J]. Research policy, 2008, 37(3): 407-29.

Barney J. Firm resources and sustained competitive advantage [J]. Journal of management, 1991, 17(1): 99-120.

Braun E, Wield D. Regulation as a means for the social control of technology [J]. Technology Analysis & Strategic Management, 1994, 6(3): 259-72.

Cainelli, G. , & Montresor, S. . (2011). Environmental innovations, local networks and internationalization. Openloc Working Papers, 19(8): 697-734.

Chen, Y. S. , Lai, S. B. , & Wen, C. T. . (2006). The influence of green innovation performance on corporate advantage in taiwan. Journal of Business Ethics, 67(4), 331-339.

Chen I J, Paulraj A, Lado A A. Strategic purchasing, supply management, and firm performance [J]. Journal of operations management, 2004, 22(5):505-523.

Chiou, T. Y. , Chan, H. K. , Lettice, F. , & Chung, S. H. . (2011). The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in taiwan. Transportation Research Part E Logistics & Transportation Review, 47(6), 822-836.

Contractor F J, Kundu S K, Hsu C-C. A three-stage theory of international expansion: The link between multinationality and performance in the service sector [J]. Journal of international business studies, 2003, 34: 5-18.

Danneels, E. The dynamics of product innovation and firm competences[J]. Strategic Management Journal, 2002,23(12): 1095-1121.

De Marchi V. Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms [J]. Research policy, 2012, 41(3): 614-23.

Dunning J H. Toward an Eclectic Theory of International Production: Some Empirical Tests [J]. Journal of International Business Studies, 1980, 11(1): 9-31.

Elkington J. Cannibals with Forks: The Triple Bottom Line of 21st Century Business. Gabriola Island, BC [J]. Environmental Quality Management, 1998, 8(1): 37-51.

Gao L. Research on the Impact of R&D Internationalization on GreenInnovation Capability——Based on the Moderation Effectof Financial Flexibility. (D), Central University of Finance and Economics, 2022

Gomes L, Ramaswamy K. An empirical examination of the form of the relationship between multinationality and performance [J]. Journal of international business studies, 1999, 30: 173-87.

Hitt M A, Hoskisson R E, Kim H. International diversification: Effects on innovation and firm performance in product-diversified firms [J]. Academy of Management journal, 1997, 40(4): 767-98.

Horbach J. Determinants of environmental innovation—New evidence from German panel data sources [J]. Research policy, 2008, 37(1): 163-73.

Hu, Y., Sun, S., & Dai, Y. (2021). Environmental regulation, green innovation, and international competitiveness of manufacturing enterprises in China: From the perspective of heterogeneous regulatory tools.[J] PLoS One, 16(3), e0249169.

Hu Z Y, Zhou J K，LI Y. Corporate behavior related to the overseas market and green technology innovation under the dual circulation developmentpattern[J]. China population, resources and environment, 2023, 33(5): 16-26.

Huang J C, Zhu G S. The Chinese Green Development Model: Public Procurement andCorporate Green Innovation [J]. The Journal of World Economy, 2023, 46(11): 54-78.

Huo C, Hameed J, Zhang M, et al. Modeling the impact of corporate social responsibility on sustainable purchase intentions: insights into brand trust and brand loyalty [J]. Economic research-Ekonomska istraživanja, 2022, 35(1): 4710-39.

Johanson J, Vahlne J-E. The Uppsala Internationalization Process Model: From liability of foreigness to liability of outsidership [J]. Journal of International Business Studies, 1977, 8(1): 23-32.

Kang J-W, Namkung Y. The effect of corporate social responsibility on brand equity and the moderating role of ethical consumerism: The case of Starbucks [J]. Journal of Hospitality & Tourism Research, 2018, 42(7): 1130-51.

Kim I, Pantzalis C, Zhang Z. Multinationality and the value of green innovation [J]. Journal of Corporate Finance, 2021, 69, 101996.

Koopman R , Wang Z , Wei S J .Tracing Value-Added and Double Counting in Gross Exports[J].Social Science Electronic Publishing, 2014, 104(2):459-494.

Kusterer M B, Hussain S S. Innovation and corporate sustainability:An investigation into the process of change in the pharmaceuticals industry[J]. Business Strategy and the Environment, 2001, 10: 300-316.

Li Q Y, Xiao Z H.Heterogeneous Environmental Regulation Tools and Green InnovationIncentives: Evidence from Green Patents of Listed Companies[J].Economic Research Journal,2020,55(09):192-208.

Linde P C V D. Toward a New Conception of the Environment-Competitiveness Relationship [J]. Journal of Economic Perspectives, 1995, 9(4): 97-118.

Miska C, Witt M A, Stahl G K. Drivers of Global CSR Integration and Local CSR Responsiveness: Evidence from Chinese MNEs [J]. Business Ethics Quarterly, 2016, 26(03): 317-45.

Qin A, Sun Y L, Wang Y P Teng F. Analysis on the Development Trend of International GreenTechnology under the Background of Carbon Neutrality[J].World Sci-Tech R & D,2021,43(04):385-402.

Rennings K .Redefining innovation -- eco-innovation research and the contribution from ecological economics[J].Ecological Economics, 2000, 32(2):p.319-332.

Silvestre B S. A hard nut to crack! Implementing supply chain sustainability in an emerging economy [J]. Journal of cleaner production, 2015,( 96):171-81.

Sullivan D. Measuring the degree of internationalization of a firm [J]. Journal of international business studies, 1994, 25(2): 325-42.

Sun, Z. , Sun, X. , & Dong, Y.. Does negative environmental performance feedback induce substantive green innovation? the moderating roles of external regulations and internal incentive [J]. Corporate Social Responsibility & Environmental Management, 2024, 31(4).

Tomorrow A G. Sustainability report [R]. 2023

Wang A H, Ji H D. Research on the Indicators System for Enterprise Sustainable Development [J]. Ecological Economy, 2000, (01): 17-20.

Wagner M. Corporate performance implications of extended stakeholder management: New insights on mediation and moderation effects [J]. Ecological Economics, 2011, 70(5): 942-50.

Wagner M, Llerena P. Eco-innovation through integration, regulation and cooperation: comparative insights from case studies in three manufacturing sectors [J]. Industry and Innovation, 2011, 18(8): 747-64.

Xi L S, Zhao H.Senior Executive Dual Environmental Cognition and Green Innovation on Enterprise Sustainable Development Performanc[J].Business and Management Journal,2022,44(03):139-158.

Xiao H J, Yang Z& Ling H C.(2022).Is Corporate Social Responsibility Conducive to Green Innovation. Economic Perspectives,(08),117-132.

Xing R X, Li B, Guo Y C.Quarterly Journal of Economics and Management[J].Quarterly Journal of Economics and Management, 2024,3(1):247-268.

Xu H, Wang S Q, Yang J D(2025).How do Chinese Private Steel Enterprises Identify GreenOpportunities in Overseas Markets under Carbon FootprintManagement? A Case Study from the Perspective ofGreen Affordance[J/OL].Foreign Economics & Management, 1-20.

Zhang S F, Bu M L. Environmental Regulation，Environmental ProtectionInvestment and Productivity：An EmpiricalStudy Based on Questionnaire of Enterprises in China [J]. Nankai Economic Studies, 2011,(02):129-146.

Zhang Z J, Qiang. Green innovation and firm performance: Evidence from listed companies in China [J]. Resources, Conservation and Recycling, 2019, 144



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