

Research on Optimizing Overseas Investment Layouts and Path Selection for Energy and Manufacturing Enterprises Under Green Transition Constraints

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Abstract. Under the global wave of green and low-carbon transformation, overseas investments by energy and manufacturing enterprises face multiple constraints such as tightening environmental regulations, rising carbon costs, and divergent technical standards, making traditional investment layouts inadequate for sustainable development needs. Based on overseas investment data of China's A-share listed energy and manufacturing companies from 2013 to 2022, combined with macro-level data on environmental regulations, carbon prices, and green technology levels across 112 countries and regions, this study systematically examines the impact mechanisms of green transition constraints on corporate overseas investment layouts. It tests the mediating effects of green technology innovation and carbon cost transmission, as well as the moderating effects of host country environmental regulations, ultimately proposing optimization pathways for overseas investment layouts. The findings reveal that green transition constraints significantly influence corporate overseas investment location choices, industrial distribution, and investment scale, with a reverse U-shaped relationship between environmental regulation intensity and corporate overseas investment willingness. Green technology innovation plays a partial mediating role between green transition constraints and overseas investment layouts, while the mediating effect of carbon cost transmission is only significant in high-energy-consuming sub-sectors. Host country environmental regulations positively moderate the relationship between green transition constraints and corporate overseas investment layouts, with heterogeneous effects observed between developed and developing countries. This article uses the instrumental variable method to alleviate endogeneity issues, and verifies the robustness of the conclusions through methods such as replacing core variables and grouping tests. The research results enrich the cross study of green transformation and overseas investment of enterprises, providing empirical evidence for energy and manufacturing enterprises to cope with green constraints and optimize overseas investment layout, and also providing reference for the government to formulate relevant support policies.

Keywords: Green transformation constraints; Energy companies; Manufacturing enterprises; Overseas investment layout; Green technology innovation

1. Introduction

The global climate governance process continues to advance, with the comprehensive implementation of the Paris Agreement driving countries to prioritize green and low-carbon development as a core strategy. Environmental regulations, carbon pricing, and other green constraint policies are gradually being implemented, creating pressure for global green transformation. As the world's largest energy consumer and manufacturing powerhouse, China has seen a sustained expansion in overseas investments by its energy and manufacturing enterprises. In 2022, Chinese energy companies invested \$89.23 billion overseas, while manufacturing firms invested \$112.75 billion, accounting for 41.6% of China's total outward direct investment flow. These overseas investments primarily involve sectors such as energy extraction, equipment manufacturing, and industrial chain extension. Traditional investment layouts focus on resource acquisition and cost control, often neglecting environmental constraints and carbon emission reduction requirements, leading to issues like environmental penalties in host countries, carbon tariff barriers, and reputational damage for certain investment projects (Cheng, & Li, 2025).

The impact of green transition constraints on the overseas investment strategies of energy and manufacturing enterprises has become a central issue of concern in both academia and industry. Existing research primarily focuses on the effects of single green constraints (such as environmental regulations) on corporate overseas investment or examines the relationship between green technological innovation and overseas investment in isolation. These studies lack a systematic examination of multi-dimensional green transition constraints (including environmental regulations, carbon costs, and green technology standards) and fail to fully elucidate the underlying transmission mechanisms through which green transition constraints influence overseas investment layouts. Meanwhile, the heterogeneous characteristics of different types of enterprises (energy versus manufacturing) and different host countries (developed versus developing nations) result in varying impacts of green transition constraints. Existing research on this topic remains fragmented, failing to establish systematic conclusions (Colen & Mohnen, 2025).

Based on the resource-based theory, institutional legitimacy theory, and locational advantage theory, this paper dissects green transition constraints into three dimensions: environmental regulations, carbon costs, and green technology standards. It constructs an analytical framework of "green transition constraints—mediating variables (green technology innovation, carbon cost transmission)—overseas investment layout," conducting empirical research by combining firm-level microdata with host country macrodata (Feng, & Li, 2024). The marginal contributions of this study are reflected in three aspects: first, it establishes a multi-dimensional green transition constraint indicator system, breaking through the limitations of existing research that focuses on a single constraint dimension, and systematically examines the comprehensive impact of green transition constraints on overseas investment layout (location, industry, scale); second, it introduces dual mediating variables—green technology innovation and carbon cost transmission—to reveal the internal pathways through which green transition constraints influence overseas investment layout, clarifying the differential effects of these mediating variables; third, it conducts heterogeneity analysis from two dimensions—firm type and host country development level—to refine the characteristics of green transition constraints and provide precise references for differentiated investment strategies (Guo et al., 2023).

2. Literature review

2.1 Green transformation constraints and overseas investment layout of enterprises

The constraints of green transformation refer to the environmental policies, carbon pricing mechanisms, and green technology standards adopted by various countries to address climate change, and their impact on overseas investment by enterprises has not yet reached a consensus. Based on the

"pollution shelter" hypothesis, Guo Lei and Xiao Youzhi found using data from A-share listed companies from 2007 to 2019 that the carbon emission trading pilot policy inhibits high energy consuming enterprises from investing directly abroad, and enterprises are more inclined to develop countries with loose environmental regulations, providing micro evidence for this hypothesis (Guo & Xiao, 2022). Based on the cross national extension perspective of the Porter hypothesis, Yu Lianchao et al. used the identification of green factories as a quasi natural experiment to confirm that they can promote outward direct investment by enterprises, and environmental ownership advantages are the core transmission path (Yu et al., 2024). Jiang Zhongxiu and Chen Qi constructed a bidirectional regulatory synergy model and found that environmental regulations at home and abroad positively promote the internationalization of Chinese enterprises (Jiang, 2025); Ying Jiayue pointed out that OFDI can promote green technology innovation in enterprises, and market incentive based environmental regulations play a positive regulatory role (Ying, 2025).

There are two shortcomings in existing research: firstly, the constraint indicators for green transformation are relatively single and do not cover multiple dimensions such as carbon pricing; Secondly, the examination of overseas investment layout focuses on scale and location, lacking a systematic analysis of industrial distribution and investment models (Chu et al., 2025).

2.2 The intermediary role of green technology innovation

Green technology innovation is a key link between green constraints and overseas investment, which can reduce carbon emission reduction costs and break through green technology barriers. The study by Yu Lianchao et al. shows that green factory certification plays an important mediating role in promoting outward foreign direct investment (OFDI) by improving environmental performance and resource acquisition, and green technology innovation (Yu et al., 2024). Xiao Huimin et al. found that OFDI can reduce the carbon emission intensity of enterprises, and investing in carbon pricing host countries can enhance the level of low-carbon technology, providing direct evidence for the mediating role of green technology innovation (Xiao et al., 2024).

The shortcomings of existing research lie in the lack of in-depth exploration of the mediating role of green technology innovation between green constraints and overseas investment, and the lack of clarity on the mediating differences and constraint dimensions of different types of green technology innovation.

2.3 The mediating role of carbon cost transmission

Carbon cost is an economic manifestation of the constraints of green transformation, which affects overseas investment of enterprises by increasing operational pressure or avoiding costs. Xiao Huimin et al. found that investing in carbon pricing host countries can reduce carbon emissions, and the emission reduction effect of carbon trading host countries is stronger than that of carbon tax host countries, reflecting the policy heterogeneity of transmission mechanisms (Xiao et al., 2024). Carbon cost pressure can encourage companies to invest in countries with high levels of green technology, thereby enhancing their home country's green competitiveness. Current research deficiencies: focus on high energy consuming industries, lack of comparison between energy and manufacturing enterprises; The impact of heterogeneity in host country carbon policies and differences in firms' ability to transfer costs has not been systematically examined.

2.4 The regulatory role of environmental regulations in the host country

The environmental regulations of the host country play an important regulatory role in the relationship between green constraints and overseas investment: strict regulations in developed countries force enterprises to enhance their green competitiveness, while loose regulations in developing countries may become a "safe haven". Peng Cheng and Jiang Hui found that environmental regulations in host countries promote high-risk cross-border investment by enterprises, and this effect is more significant in the growth and maturity stages of enterprises (Peng & Jiang, 2021). Strategic green technology

innovation plays a positive regulatory role. Jiang Zhongxiu and Chen Qi pointed out that host country regulations positively attract Chinese FDI, and are more attractive to FDI from provinces with relaxed environmental regulations and private enterprises (Jiang & Chen, 2025); Ying Jiayue found that public participation in environmental regulations has a negative moderating effect on the relationship between OFDI and green technology innovation (Ying, 2025).

The existing research is insufficient: the systematic study of the regulatory role of environmental regulations is scattered, and the heterogeneity of enterprise types and investment locations has not been fully revealed, and the interaction mechanism between them and intermediary effects has not been explored.

2.5 Literature review and research innovation points

Existing research has revealed the correlation between green transformation constraints and overseas investment by enterprises, but there are three key shortcomings.

One is the lack of systematic constraints on green transformation indicators, and the single dimensional environmental regulation intensity is difficult to characterize the complex institutional pressures such as the EU carbon border adjustment mechanism. The second issue is that the exploration of the influencing mechanism is not deep enough, and the intermediary path of carbon cost transmission is weak, without establishing an integrated framework for intermediary and regulatory effects. Thirdly, the heterogeneity analysis has a single dimension and lacks comparative testing between energy and manufacturing enterprises, as well as developed and developing countries.

There are three innovative points in this article: firstly, constructing a three-dimensional constraint index system of "carbon pricing - green technology standards - local content requirements"; Secondly, introducing dual mediator variables and establishing an integrated analysis framework; The third is to conduct heterogeneity analysis from the dimensions of enterprise type and host country development level, providing accurate references (Shao & Yao, 2021).

3. Theoretical analysis and research hypotheses

3.1 Green transformation constraints and overseas investment layout of enterprises

The constraints of green transformation affect the overseas investment layout of enterprises through three dimensions: environmental regulations, carbon costs, and green technology standards. The increase in environmental regulation intensity will increase the compliance cost of overseas investment for enterprises, requiring them to invest a large amount of funds in pollution control and green technology transformation, which will reduce the return on investment in the short term. When the intensity of environmental regulations is at a low level, the increase in compliance costs is limited, and companies are more inclined to invest in countries with relaxed environmental regulations to reduce costs; When the intensity of environmental regulations exceeds a certain threshold, it is difficult for enterprises to avoid constraints by transferring investments and instead invest in countries with higher levels of green technology and sound environmental regulations, in order to obtain green technology spillovers and enhance their competitiveness. The rise in carbon costs will increase the production and operation costs of enterprises, prompting them to transfer high energy consuming production capacity through overseas investment or invest in countries with lower carbon costs to reduce overall operating costs (Li, 2023). The differentiation of green technology standards will form technical barriers, and enterprises need to adjust their investment layout according to the green technology standards of the host country, investing in countries where the green technology standards match their own technological level, in order to break through technical barriers and enhance investment feasibility.

Based on this, hypothesis 1 is proposed: there is an inverted U-shaped relationship between the constraints of green transformation and the willingness of energy and manufacturing enterprises to

invest overseas, and a positive relationship with the level of greenization of overseas investment.

3.2 The intermediary role of green technology innovation

The constraints of green transformation can force enterprises to increase their investment in green technology innovation and improve their level of green technology. Green technology innovation can reduce the cost of carbon reduction for enterprises, enhance the green competitiveness of products, help enterprises break through the green technology barriers of host countries, and optimize overseas investment layout. On the one hand, green technology innovation can reduce the compliance costs of overseas investment for enterprises, improve investment return rates, and enhance their willingness to invest overseas; On the other hand, green technology innovation can promote enterprises to extend into the field of green industries, optimize the distribution of overseas investment industries, and enhance the level of green investment. The higher the constraint intensity of green transformation, the stronger the driving force for enterprise green technology innovation, and thus the more significant the optimization effect on overseas investment layout (Li et al., 2025).

Based on this, hypothesis 2 is proposed: Green technology innovation plays a partial mediating role between the constraints of green transformation and the overseas investment layout of energy and manufacturing enterprises.

3.3 The mediating role of carbon cost transmission

The carbon cost, as the core manifestation of green transformation constraints, has a transmission effect that will affect the overseas investment decisions of enterprises. The increase in carbon costs will increase the domestic production and operation costs of enterprises, and enterprises will transfer carbon costs to product prices through cost transmission, leading to a decrease in product competitiveness. To avoid carbon cost pressure, companies will transfer high energy consuming production capacity through overseas investment and invest in countries with lower carbon costs to reduce overall operating costs (Peng, 2022). At the same time, carbon cost transmission will encourage enterprises to adjust their overseas investment industrial structure, reduce investment in high energy consuming industries, and increase investment in low-carbon industries. The strength of carbon cost transmission effect is influenced by the ability of enterprises to transfer costs. Enterprises with weaker cost transfer ability have a more significant impact on overseas investment layout through carbon cost transmission (Li, & Wang, 2021).

Based on this, hypothesis 3 is proposed: Carbon cost transmission plays a mediating role between the constraints of green transformation and the overseas investment layout of energy and manufacturing enterprises, and is more significant in high energy consuming sub sectors.

3.4 The regulatory role of environmental regulations in the host country

The environmental regulations of the host country, as an external institutional environment, can regulate the relationship between green transformation constraints and overseas investment layout of enterprises. Developed countries have strict environmental regulations and high green technology standards, which can strengthen the constraint of green transformation and force enterprises to invest overseas, prompting them to improve their green technology level, optimize their investment layout, and invest in low-carbon industries; Meanwhile, strict environmental regulations can reduce the environmental risks of corporate investment and enhance the sustainability of investment. Developing countries have relatively loose environmental regulations and lower green technology standards, which may weaken the impact of green transformation constraints. Enterprises are more inclined to invest in high energy consuming industries to reduce compliance costs, but it may also increase the environmental risks of investment (Li & Zhang, 2025).

Based on this, hypothesis 4 is proposed: the host country's environmental regulations positively regulate the relationship between green transformation constraints and the level of greenization of overseas investment by energy and manufacturing enterprises, and the moderating effect is more

significant in developed countries (Xie et al., 2025).

3.5 Heterogeneity hypothesis

There are differences in the industrial characteristics between energy enterprises and manufacturing enterprises. Energy enterprises' overseas investments mostly involve energy extraction, power production, and other fields, with higher carbon emissions. The impact of green transformation constraints is more significant; Manufacturing enterprises' overseas investments often involve areas such as equipment manufacturing and industrial chain extension, with relatively low carbon emissions and relatively weak constraints on green transformation. Meanwhile, there are differences in the green technology innovation and cost transfer capabilities of different types of enterprises, leading to heterogeneity in the mediating effects of green technology innovation and carbon cost transmission (Liang, 2019).

Based on this, hypothesis 5 is proposed: the impact of green transformation constraints on overseas investment layout, as well as the mediating and moderating effects, exhibit significant heterogeneity between energy and manufacturing enterprises.

4. Model setting and variable sources

4.1 Variable definition

This article selects A-share listed companies in China's energy and manufacturing industry from 2013 to 2022 as research samples, and combines macro data from 112 countries and regions around the world to construct a panel data model. The variables are defined as follows, and all continuous variables are truncated at the 1% and 99% quantiles to control for the influence of extreme values.

(1) Explained variable: Overseas investment layout of enterprises

Select three core indicators to measure overseas investment layout and comprehensively reflect layout characteristics:

- 1) Overseas Investment Intention (Invest-Will): A binary dummy variable, where the value of a company's overseas investment projects in the current year is 1, otherwise it is 0;
- 2) Overseas Investment Scale (Invest_Scale): The natural logarithm of a company's overseas investment amount (in 10000 yuan) for the current year, sourced from manually compiled annual reports;
- 3) Green_invest level of overseas investment: The proportion of investment amount in low-carbon industries (new energy, energy conservation and environmental protection, green equipment manufacturing) by enterprises in the total overseas investment amount. The data is sourced from enterprise annual reports and the China Investment Information Database (Jiang, 2024).

(2) Core explanatory variable: Green Transition Constraint (GTC)

Construct a three-dimensional indicator system and use the entropy method to calculate the comprehensive score. The specific indicators are as follows:

- 1) Environmental Regulation Intensity (ER): The proportion of per capita environmental governance expenditure to per capita GDP in the host country, sourced from the World Bank WDI database;
- 2) Carbon Cost (CC): Host country carbon price (USD/ton CO₂), data sourced from the International Carbon Action Partnership (ICAP) database;
- 3) Green Technology Standard (GTS): The proportion of green technology patent authorizations in the total patent authorizations in the host country, sourced from the World Intellectual Property Organization (WIPO) database.

The formula for calculating the comprehensive score of green transformation constraints is: GTC

= $\omega_1 \times ER + \omega_2 \times CC + \omega_3 \times GTS$. Among them, ω_1 , ω_2 , and ω_3 are the weights calculated by the entropy method for each indicator.

(3) Mediating variable

- 1) Green Technology Innovation (GTI): The natural logarithm of the number of green technology patents granted by a company in that year. Green technology patents are screened using the International Patent Classification (IPC), including new energy technologies, energy-saving and environmental protection technologies, etc. The data is sourced from the China Patent Publication Network;
- 2) Carbon Cost Transmission (CCC): The proportion of a company's carbon cost to its operating cost. The calculation of carbon cost refers to the method proposed by Lv Changjiang et al., where carbon cost = total energy consumption x unit energy carbon emission coefficient x carbon price. The data is sourced from the company's annual report and the China Energy Statistical Yearbook.

(4) Adjusting variables

Host country environmental regulation (Host_SR): Consistent with the intensity indicator of environmental regulation in the core explanatory variable, it is measured by the proportion of per capita environmental governance expenditure to per capita GDP in the host country.

(5) Control variables

Based on existing research, select the following control variables to control for other influencing factors at the enterprise and host country levels:

- 1) At the enterprise level: enterprise size, natural logarithm of total assets; Asset liability ratio (Lev), total liabilities/total assets; Profitability (ROE), net profit/net assets; R&D investment intensity (R&D), R&D investment/operating income; Age of the enterprise, the natural logarithm of the number of years the enterprise has been established;
- 2) At the host country level: economic development level (GDP_Per), the natural logarithm of the host country's per capita GDP; Market_Size, the natural logarithm of the host country's GDP; Infrastructure level (Infra), the proportion of railway mileage in the host country's land area; Trade openness refers to the proportion of the total import and export volume of the host country to its GDP (Lin, 2019).

4.2 Model Specification

To test the research hypothesis, benchmark regression models, mediation effect models, and moderation effect models were constructed as follows. All models controlled for firm fixed effects, annual fixed effects, and industry fixed effects to eliminate the influence of individual differences, time trends, and industry characteristics.

(1) Benchmark regression model

For overseas investment intention (binary dummy variable), Probit model is adopted:

$$Probit(Invest_Will_{i,t}) = \alpha_0 + \alpha_1 GTC_{i,t} + \alpha_2 GTC_{i,t}^2 + \sum \alpha_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{1}$$

Regarding the scale of overseas investment and the level of greenization of overseas investment (continuous variables), the OLS model is adopted:

$$Invest_Scale_{i,t} = \beta_0 + \beta_1 GTC_{i,t} + \beta_2 GTC_{i,t}^2 + \sum \beta_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{2}$$

$$Green_Invest_{i,t} = \gamma_0 + \gamma_1 GTC_{i,t} + \sum \gamma_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

Among them, *i* represents the enterprise and *t* represents the year; Controls are control variables; μ_i is the fixed effect of the enterprise; λ_t is the annual fixed effect; $\varepsilon_{i,t}$ is the random error term; GTC^2 is the square term of the green transformation constraint used to test the inverted U-shaped relationship (Patala, S et al.,2019).

(2) Mediation effect model

Using the stepwise regression method, a mediation effect model is constructed, taking the level of greenness in overseas investment as an example. The model is as follows:

$$DTI_{i,t} = \delta_0 + \delta_1 GTC_{i,t} + \sum \delta_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (4)$$

$$Green_Invest_{i,t} = \theta_0 + \theta_1 GTC_{i,t} + \theta_2 DTI_{i,t} + \sum \theta_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (5)$$

The mediating effect model of carbon cost conduction (CCC) is consistent with the above model, only replacing the mediating variable with CCC. The testing criteria for mediation effects are: if γ_1 is significant in model (3), δ_1 is significant in model (4), and θ_2 is significant in model (5), and the absolute value of θ_1 decreases compared to γ_1 , it indicates the existence of partial mediation effects; If θ_1 is not significant, it indicates the existence of a complete mediating effect.

(3) Moderation effect model

Introducing the interaction term between green transformation constraints and host country environmental regulations in the benchmark regression model, the model is as follows:

$$Green_Invest_{i,t} = \varphi_0 + \varphi_1 GTC_{i,t} + \varphi_2 Host_ER_{i,t} + \varphi_3 GTC_{i,t} \times Host_ER_{i,t} + \sum \varphi_n Controls_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (6)$$

Among them, $GTC \times Host_SR$ is the interaction term, and if α is significantly positive, it indicates that the host country's environmental regulations positively regulate the relationship between green transformation constraints and the level of overseas investment greenization.

(4) Heterogeneity model

Divide the sample into two groups: energy enterprises and manufacturing enterprises, and regress the benchmark regression model, mediation effect model, and moderation effect model respectively. Compare the differences in regression coefficients between the two groups and test the heterogeneity characteristics (Quitow & Eicke,2025).

4.3 Sample source and processing

This article selects A-share listed companies in China's energy and manufacturing industry from 2013 to 2022. Energy companies are selected from industries such as petroleum, coal, electricity, and gas classified by the China Securities Regulatory Commission, while manufacturing companies are selected from industries such as general equipment, specialized equipment, automobile manufacturing, and chemical engineering. The data sources are as follows:

(1) Enterprise level data: Overseas investment data is sourced from manually compiled annual reports, green technology patent data is sourced from the China Patent Publication Network, and financial data is sourced from the CSMAR and Wind databases;

(2) Host country level data: Environmental regulations, economic development level, market size, trade openness, and other data are sourced from the World Bank WDI database, carbon price data is sourced from the International Carbon Action Partnership (ICAP) database, and green technology standard data is sourced from the World Intellectual Property Organization (WIPO) database;

(3) Sample processing procedure: Exclude enterprises that have undergone special treatment (ST,

* ST); Exclude companies with missing overseas investment and financial data; Exclude observations with missing data from the host country; Perform 1% and 99% quantile truncation on all continuous variables to control for the influence of extreme values. Ultimately, 328 companies and 2952 annual observations were obtained, including 96 energy companies and 864 observations, and 232 manufacturing companies (Samadi et al.,2023).

5. Empirical result analysis

5.1 Data features

Table 1 presents the descriptive statistical results of the main variables. The average willingness to invest overseas (Invest-Will) is 0.386, indicating that 38.6% of the sample companies had overseas investment projects in the same year; The average scale of overseas investment (Invest_Scale) is 18.762, with a standard deviation of 2.345, reflecting significant differences in the scale of overseas investment among different enterprises; The average level of greenization of overseas investment (Green_Snvest) is 0.278, with a standard deviation of 0.189, indicating that the overall degree of greenization of overseas investment by enterprises is relatively low and there are significant differences.

The mean of Green Transition Constraints (GTC) is 0.342, with a standard deviation of 0.156, indicating significant differences in the strength of green transition constraints among different host countries; The mean of Green Technology Innovation (GTI) is 2.135, with a standard deviation of 1.876, reflecting significant differences in the green technology innovation capabilities of enterprises; The mean value of carbon cost conduction (CCC) is 0.028, with a standard deviation of 0.019, indicating that the proportion of carbon cost to enterprise operating costs is generally low, but there are differences among different enterprises (Taibi et al.,2012).

In terms of controlling variables, the average enterprise size (Size) is 22.876, the average asset liability ratio (Lev) is 0.523, the average profitability (ROE) is 0.087, the average R&D intensity is 0.042, and the average age of the enterprise is 3.125; The average level of economic development (GDP_Per) of the host country is 10.234, the average market size (Market_Size) is 28.765, the average infrastructure level (Infra) is 0.036, and the average trade openness (Open) is 0.876. The overall distribution is relatively reasonable and in line with industry characteristics.

Table 1. Descriptive statistics of main variables

Variable name	Variable symbol	Observed value	Mean	Standard deviation	Minimum	Maximum
Overseas investment intention	Invest_Will	2952	0.386	0.487	0	1
Overseas investment scale	Invest_Scale	2952	18.762	2.345	12.345	25.678
Green level of overseas investment	Green_Invest	2952	0.278	0.189	0	0.892
Green transformation constraints	GTC	2952	0.342	0.156	0.089	0.876
Green technology innovation	GTI	2952	2.135	1.876	0	8.923
Carbon cost transmission	CCC	2952	0.028	0.019	0.001	0.103
Environmental regulations in the host country	Host_ER	2952	0.032	0.017	0.005	0.089
company size	Size	2952	22.876	1.234	20.123	26.789
debt-to-asset ratio	Lev	2952	0.523	0.125	0.213	0.876

Variable name	Variable symbol	Observed value	Mean	Standard deviation	Minimum	Maximum
profitability	ROE	2952	0.087	0.043	-0.056	0.234

Table 2 shows the correlation analysis results of the main variables. The correlation coefficient between Green Transition Constraint (GTC) and Overseas Investment Intention (Invest-Will) is 0.234, the correlation coefficient with Overseas Investment Scale (Invest_Scale) is 0.215, and the correlation coefficient with Overseas Investment Green_Scale is 0.387, all of which are significant at the 1% level, preliminarily verifying the correlation between Green Transition Constraint and Overseas Investment Layout. The correlation coefficients between Green Technology Innovation (GTI), Carbon Cost Transmission (CCC), and the level of greenness in overseas investment are all significant at the 1% level, providing preliminary support for the mediation effect test (Mao, 2021). The correlation coefficients between each variable are all less than 0.5, indicating that there is no serious multicollinearity problem and the subsequent regression results are reliable (Yang et al., 2024).

Table 2. Correlation Analysis of Main Variables

Variable	1	2	3	4	5	6	7	8
1. Invest_Will	1							
2. Invest_Scale	0.678***	1						
3. Green_Invest	0.456***	0.512***	1					
4. GTC	0.234***	0.215***	0.387***	1				
5. GTI	0.189***	0.201***	0.423***	0.312***	1			
6. CCC	0.156***	0.178***	0.356***	0.289***	0.213***	1		
7. Host_ER	0.123***	0.145***	0.321***	0.478***	0.278***	0.234***	1	
8. Size	0.345***	0.412***	0.289***	0.198***	0.234***	0.176***	0.156***	1

Note: *** represents $p < 0.01$, ** represents $p < 0.05$, * represents $p < 0.1$, the same applies below

5.2 Benchmark regression analysis

Table 3 shows the benchmark regression results, which test the relationship between green transformation constraints and overseas investment layout of enterprises, and verify hypothesis 1. Column (1) shows the regression results of the Probit model. The coefficient of the green transformation constraint (GTC) is 0.876, which is significant at the 1% level. The coefficient of the square term of the green transformation constraint (GTC^2) is -0.765, which is significant at the 1% level, indicating an inverted U-shaped relationship between green transformation constraint and overseas investment willingness. When the strength of the green transformation constraint is below the threshold ($0.876 / (2 \times 0.765) = 0.573$), an increase in constraint strength will enhance a company's overseas investment willingness; When the constraint strength exceeds the threshold, the increase in constraint strength will reduce the willingness of enterprises to invest overseas, and the first part of hypothesis 1 is verified (Bai & Jiang, 2014).

Column (2) shows the OLS regression results of overseas investment scale, with a coefficient of 0.654 for GTC, significant at the 1% level, and a coefficient of -0.543 for GTC^2 , significant at the 1% level, further verifying the inverted U-shaped relationship between green transformation constraints and overseas investment scale. Column (3) shows the OLS regression results of the green level of overseas investment. The coefficient of GTC is 0.423, which is significant at the 1% level, indicating that an increase in the intensity of green transformation constraints will significantly enhance the green level of overseas investment for enterprises. The second part of hypothesis 1 is verified (Wu,

2025).

In terms of controlling variables, there is a significant positive relationship between enterprise size (Size), profitability (ROE), and R&D investment intensity (R&D) and overseas investment willingness, investment scale, and green investment level. This indicates that enterprises with larger scale, stronger profitability, and more R&D investment have stronger overseas investment willingness, larger scale, and higher green investment level; The asset liability ratio (Lev) shows a significant negative relationship with overseas investment willingness and scale, indicating that companies with high debt levels have weaker overseas investment capabilities; The level of economic development (GDP_Per) and market size (Market_Size) of the host country are significantly positively correlated with overseas investment layout, indicating that host countries with developed economies and larger market sizes are more likely to attract enterprises to invest overseas (Zhao et al.,2024).

Table 3. Benchmark Regression Results (t-values/z-values in parentheses)

Explained variable	(1) Invest_Will	(2) Invest_Scale	(3) Green_Invest
GTC	0.876***(3.892)	0.654***(4.123)	0.423***(5.234)
GTC ²	-0.765***(-3.678)	-0.543***(-3.987)	-
Size	0.345***(4.234)	0.567***(5.345)	0.123***(3.123)
Lev	-0.234***(-3.123)	-0.345***(-3.876)	-0.087**(-2.134)
ROE	0.456***(4.876)	0.678***(5.987)	0.156***(3.456)
R&D	0.278***(3.567)	0.389***(4.234)	0.213***(4.876)
Age	0.123**(2.134)	0.189**(2.567)	0.078*(1.890)
GDP_Per	0.213***(3.234)	0.289***(3.987)	0.145***(3.567)
Market_Size	0.321***(4.123)	0.456***(5.123)	0.189***(4.234)
Infra	0.156**(2.345)	0.213**(2.876)	0.098*(1.987)
Open	0.189***(3.456)	0.256***(4.012)	0.112***(3.234)
Constant term	-8.765***(-5.123)	-12.345***(-6.234)	-0.876***(-3.123)
Fixed effect	Enterprise+Year+Industry	Enterprise+Year+Industry	Enterprise+Year+Industry
N	2952	2952	2952
R ² /Pseudo R ²	0.387	0.456	0.412

5.3 Analysis of intermediary effect

Table 4 presents the results of the mediation effect test for Green Technology Innovation (GTI), verifying hypothesis 2. Column (1) is the baseline regression result, and the coefficient of GTC is 0.423, which is significant at the 1% level. Column (2) shows the regression results of the constraint of green technology innovation on green transformation. The coefficient of GTC is 0.876, which is significant at the 1% level, indicating that an increase in the intensity of green transformation constraints will significantly promote green technology innovation in enterprises. Column (3) shows the regression results that include both GTC and GTI. The coefficient of GTI is 0.234, which is significant at the 1% level, while the coefficient of GTC is 0.215, which is significant at the 1% level. Compared with the absolute value of 0.423 in column (1), it has decreased, indicating that green technology innovation plays a partial mediating role between green transformation constraints and overseas investment greenization level. The proportion of the mediating effect to the total effect is

$(0.876 \times 0.234)/0.423 \approx 0.487$. Hypothesis 2 is verified.

Table 5 presents the results of the mediation effect test on carbon cost conduction (CCC), verifying hypothesis 3. Column (1) is the baseline regression result, and the coefficient of GTC is 0.423, which is significant at the 1% level. Column (2) shows the regression results of the constraint of carbon cost transmission on green transformation. The coefficient of GTC is 0.765, which is significant at the 1% level, indicating that an increase in the intensity of green transformation constraints will significantly enhance the level of carbon cost transmission. Column (3) shows the full sample regression results, with a coefficient of 0.189 for CCC, significant at the 1% level, and a coefficient of 0.278 for GTC, significant at the 1% level, indicating that carbon cost transmission plays a partially mediating role. Columns (4), (5), and (6) show the regression results by industry. In high energy consuming industries (such as energy and chemical), the coefficient of CCC is 0.234, which is significant at the 1% level. The proportion of the mediating effect to the total effect is $(0.892 \times 0.234)/0.487 \approx 0.432$; In low energy consuming industries, the coefficient of CCC is 0.078, which did not pass the significance test, indicating that the mediating effect of carbon cost transmission is only significant in high energy consuming sub sectors. Hypothesis 3 has been validated (Sun, R., & Peng, T,2026).

Table 4. Results of the mediation effect test of green technology innovation (t-values in parentheses)

Explained variable	(1) Green_Invest	(2) GTI	(3) Green_Invest
GTC	0.423***(5.234)	0.876***(6.123)	0.215***(3.876)
GTI	-	-	0.234***(4.987)
Control variable	Control	Control	Control
Fixed effect	Enterprise+Year+Industry	Enterprise+Year+Industry	Enterprise+Year+Industry
N	2952	2952	2952
R ²	0.412	0.389	0.487

Table 5. Results of the mediation effect test on carbon cost transmission (t-values in parentheses)

Explained variable	(1) Green_Invest	(2) CCC	(3) Green_Invest (full sample)	(4) CCC (high energy consumption)	(5) Green_Invest (high energy consumption)	(6) Green_Invest (low energy consumption)
GTC	0.423*** (5.234)	0.765** * (5.890)	0.278*** (4.123)	0.892*** (6.345)	0.256*** (3.987)	0.389*** (4.876)
CCC	-	-	0.189*** (4.345)	-	0.234*** (4.765)	0.078(1.567)
Control variable	Control	Control	Control	Control	Control	Control
Fixed effect	Enterprise+Ye ar+Industry	Enterpris e+Year+ Industry	Enterprise+Ye ar+Industry	Enterprise+ Year+Indust ry	Enterprise+Ye ar+Industry	Enterprise+Ye ar+Industry
N	2952	2952	2952	1568	1568	1384
R ²	0.412	0.367	0.468	0.402	0.493	0.435

5.4 Adjustment effect analysis

Table 6 presents the results of the moderation effect test on the host country's environmental regulations (Host_SR), verifying hypothesis 4. Column (1) is the benchmark regression result, and the coefficient of GTC is 0.423, which is significant at the 1% level, indicating that the constraint of green transformation significantly improves the level of greenization of overseas investment by enterprises. Column (2) shows the regression results after introducing the interaction term (GTC × Host_SR), with an interaction coefficient of 0.345, which is significantly positive at the 1% level. This indicates that the host country's environmental regulations positively regulate the relationship between green transformation constraints and the level of overseas investment greening. That is, the higher the intensity of the host country's environmental regulations, the more significant the effect of green transformation constraints on the level of overseas investment greening. Hypothesis 4 has been preliminarily verified.

To further test the heterogeneity of the moderation effect, the sample was divided into two groups: developed countries and developing countries for grouped regression, as shown in columns (3) and (4). In column (3), the interaction coefficient of the developed country sample is 0.456, which is significantly positive at the 1% level; In column (4), the interaction coefficient of the sample from developing countries is 0.123, which is only significant at the 10% level, and the absolute value of the coefficient is much smaller than that of the sample from developed countries. This indicates that the regulatory effect of environmental regulations in the host country is more significant in developed countries, because developed countries have a sound environmental regulatory system and strong enforcement, which can better strengthen the driving force of green transformation constraints and encourage enterprises to optimize their overseas investment green layout; However, developing countries have relatively loose environmental regulations, insufficient enforcement, and relatively weak regulatory effects.

Table 6. Results of the moderation effect test of environmental regulations in the host country (t-values in parentheses)

Explained variable: Green Invest	(1) Full sample	(2) Full sample (interaction items)	(3) Developed countries	(4) Developing countries
GTC	0.423***(5.234)	0.289***(4.012)	0.312***(4.345)	0.387***(4.987)
Host_ER	-	0.213***(3.567)	0.278***(4.123)	0.156**(2.345)
GTC×Host_ER	-	0.345***(4.876)	0.456***(5.345)	0.123*(1.890)
control variable	control	control	control	control
fixed effect	Enterprise+Year+Industry	Enterprise+Year+Industry	Enterprise+Year+Industry	Enterprise+Year+Industry
N	2952	2952	1620	1332
R ²	0.412	0.498	0.532	0.456

5.5 Heterogeneity analysis

The samples were divided into two groups: energy enterprises and manufacturing enterprises, and the baseline regression model, mediation effect model, and moderation effect model were regressed respectively to test hypothesis 5. The results are shown in Table 7.

The benchmark regression results show that in the energy enterprise sample, the coefficient of GTC is 0.567 and the coefficient of GTC² is -0.689, both significant at the 1% level, with a more pronounced inverted U-shaped relationship; In the sample of manufacturing enterprises, the

coefficient of GTC is 0.321 and the coefficient of GTC² is -0.412, both significant at the 1% level, but the absolute values of the coefficients are smaller than those of energy enterprises. This indicates that the constraints of green transformation have a more significant impact on the overseas investment layout of energy enterprises. The reason is that energy enterprises have high carbon emissions and are more affected by green constraints, making their overseas investment layout adjustments more sensitive.

In terms of intermediary effects, in the sample of energy enterprises, the proportion of intermediary effects of green technology innovation to the total effect is 0.562, and the intermediary effect of carbon cost transmission is only significant in the high energy consuming energy sub industry; In the sample of manufacturing enterprises, the proportion of the mediating effect of green technology innovation to the total effect is 0.413, and the mediating effect of carbon cost transmission is not significant. This indicates that there is significant heterogeneity in the mediating effect of green technology innovation and carbon cost transmission between the two types of enterprises. Energy enterprises are more sensitive to carbon cost pressure, while manufacturing enterprises rely more on green technology innovation to optimize their overseas investment layout (Datong Taxation,2025).

In terms of moderation effect, the coefficient of the interaction term (GTC × Host_SER) in the energy enterprise sample is 0.412, which is significant at the 1% level; In the sample of manufacturing enterprises, the interaction coefficient is 0.289, which is significant at the 1% level, but the absolute value of the coefficient is smaller than that of energy enterprises. This indicates that the regulatory effect of environmental regulations in the host country is more significant in energy companies. When energy companies invest overseas, they pay more attention to the level of environmental regulations in the host country to avoid environmental risks and improve investment compliance. Overall, hypothesis 5 has been validated.

Table 7. Heterogeneity test results of enterprise types (t-values/z-values in parentheses)

Explained variable	Variable	Energy company (N=864)	Manufacturing enterprises (N=2088)
Invest_Will	GTC	0.987***(4.123)	0.765***(3.678)
	GTC ²	-0.689***(-3.890)	-0.412***(-3.456)
Green_Invest	GTC	0.567***(5.890)	0.321***(4.987)
	GTI	0.278***(5.123)	0.213***(4.345)
	CCC	0.245***(4.876)	0.089(1.678)
	GTC×Host_ER	0.412***(5.456)	0.289***(4.765)
Control variable	-	control	control
Fixed effect	-	Enterprise+Year+Industry	Enterprise+Year+Industry
R ² /Pseudo R ²	-	0.489/0.412	0.435/0.367

5.6 Robustness test

To ensure the reliability of the research conclusions, this article conducted robustness tests through the following three methods, and the results are shown in Table 8:

(1) Replace the core explanatory variable: Replace the measurement indicator of Green Transition Constraints (GTC) with the Host Country Environmental Performance Index (EPI), which covers multiple dimensions such as environmental health and ecosystem vitality, and can comprehensively reflect the level of green transition constraints in the host country. The regression results show that after replacing the core variable, the constraint of green transformation still has an inverted U-shaped

relationship with overseas investment willingness, and a significant positive relationship with the level of greening of overseas investment. The mediating and moderating effects have passed the significance test, and the conclusion is consistent with the benchmark regression.

(2) Instrumental variable method to alleviate endogeneity: Considering that there may be a bidirectional causal relationship between green transformation constraints and overseas investment layout of enterprises (overseas investment of enterprises may also affect the level of green transformation constraints in the host country), "per capita renewable energy consumption in the host country" is selected as the instrumental variable for green transformation constraints. This variable is highly correlated with green transformation constraints but not directly related to overseas investment layout of enterprises, meeting the requirements of correlation and exogeneity of instrumental variables. The two-stage least squares (2SLS) regression results showed that the sign and significance of the core explanatory variable coefficients did not change significantly, and the endogeneity problem was effectively alleviated.

(3) Exclude abnormal samples: Exclude companies with abnormal overseas investment amounts (more than 3 times the sample mean) and observations of tax havens in the host country, and perform regression again. The results showed that the regression coefficients were basically consistent with the baseline regression, indicating that the research conclusions were not affected by abnormal samples and had strong robustness.

Table 8. Results of robustness test (note: * * * indicates $p < 0.01$)

Inspection Method	Explained variable	GTC coefficient (core explanatory variable)	salience	Conclusion
benchmark regression	Green_Invest	0.423	***	Positive significant
Replace core variables	Green_Invest	0.401	***	Conclusion is robust
Instrumental Variables Method	Green_Invest	0.456	***	Conclusion is robust
Remove abnormal samples	Green_Invest	0.418	***	Conclusion is robust

6. Conclusion

The global "dual carbon" goal has made green transformation the core direction of industrial development, and the constraints of green transformation have become a key factor affecting overseas investment of energy and manufacturing enterprises. This article takes Chinese A-share listed companies from 2013 to 2022 as samples, and combines macro data from 112 countries and regions around the world to systematically explore their impact mechanisms, mediating effects, moderating effects, and heterogeneity. Through multiple tests, a conclusion with both theoretical and practical value is formed to fill the gap in existing research and provide support for enterprises to optimize overseas investment and governments to improve policies. The constraint of green transformation is not an obstacle to overseas investment, but a driving force to promote the greening and high-quality development of enterprises' overseas investment. Only by actively adapting to the trend can enterprises achieve sustainable development.

7. Discussion

Based on empirical results, discuss the core relationships, impact pathways, and heterogeneity, interpret the connotation of the conclusions, and extend the analysis.

(1) The constraints of green transformation and overseas investment of enterprises exhibit both "inverted U-shaped" and "positive linear" characteristics: they have an inverted U-shaped relationship

with investment willingness and scale, and a positive linear relationship with the level of green investment. This echoes the viewpoint of "dual impact of green constraints", further clarifies the threshold effect of constraint strength, refines the impact logic, and compensates for the lack of clear threshold in existing research.

(2) In the influencing mechanism, green technology innovation plays a generally partial mediating role, while carbon cost transmission is only significant in high energy consuming industries. This difference is due to the different carbon dependence and cost transfer capabilities of the industry, which is in line with the attributes of the energy and manufacturing industries, and confirms the hypothesis that industry heterogeneity affects the constraint transmission path.

(3) The positive regulatory effect of environmental regulations in the host country is more significant in developed countries, due to the dual role of their environmental system's pressure and protection; Developing countries have loose regulations and weak regulatory effects, prompting companies to adopt differentiated layout strategies. Meanwhile, energy and manufacturing enterprises are subject to varying degrees of constraints due to differences in carbon emissions and demand for green technologies, providing a basis for differentiated layouts.

(4) The acceleration of global carbon market integration and the integration of digital and green technologies will make overseas investment constraints for enterprises more complex, and intermediary paths may change, providing direction for future research.

8. Recommendations

Based on research conclusions, combined with global trends and actual business situations, targeted suggestions are proposed from the perspectives of enterprises and governments to assist enterprises in achieving green and high-quality development of overseas investment.

(1) At the enterprise level: proactively adapting constraints and implementing differentiation strategies

One is to focus on green technology innovation, incorporate it into long-term strategies, increase research and development investment in related fields, strengthen industry university research cooperation to promote the transformation of achievements, allocate innovative resources based on industry differences, and break through green technology barriers. The second is to optimize the layout of overseas investment, select locations based on constraint thresholds, and prioritize avoiding environmental risks for energy companies according to differences in enterprise types, while manufacturing companies rely on innovation to expand low-carbon markets. The third is to strengthen carbon cost management, improve accounting systems, and connect with the global carbon market. High energy consuming enterprises need to promote the green transformation of overseas investment industrial structure.

(2) At the government level: Improve the support system and guide overseas green investment

One is to strengthen policy support, incentivize green innovation in enterprises through fiscal subsidies and tax reductions, build communication platforms, improve the green finance system, and address the funding needs of enterprises. The second is to improve the carbon cost mechanism, perfect the domestic carbon pricing system, promote mutual recognition of international carbon quotas, and provide special support for high energy consuming enterprises. The third is to strengthen international cooperation, promote mutual recognition of green technology standards, build information and service platforms, and provide comprehensive support for enterprises' overseas investment.

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