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The Supply Chain Transmission Effect of ESG Performance of Listed Companies—A Study on the Asymmetric Impact on the Innovation of Upstream and Downstream Enterprises

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Abstract. The supply chain is the basic organizational form of enterprises' economic activities, yet the transmission effect of ESG performance within this organizational form has long not received sufficient attention. Taking Chinese A-share listed companies and their supply chain partners from 2007 to 2024 as the sample, this paper conducts an empirical test using a two-way fixed effects model. The study finds that the ESG performance of focal firms significantly promotes the innovation of downstream customers, while its impact on upstream suppliers is not significant, presenting a clear asymmetric pattern. The mechanism test shows that market power and analyst attention play a positive mediating role only on the downstream side. The heterogeneity analysis further reveals that the transmission effect is stronger in contexts such as non-state-owned enterprises, high-tech industry matching, and low customer dependence. This paper provides new evidence for understanding the supply chain spillover effect of ESG and has policy implications for guiding enterprises' green transformation and innovation collaboration.

Keywords: ESG performance, supply chain transmission, enterprise innovation, asymmetry, spillover effect

1. Introduction

Against the background of global sustainable development and China's "dual carbon" strategy, ESG has become a core corporate strategy. At the international level, the EU's new ESG rating regulations will be implemented in July 2026, and the ISSB standards have already been applied in more than 60 jurisdictions. At the domestic level, China's "dual carbon" goals and supporting policies continue to advance, the unified ESG disclosure framework for A-share listed companies has been established, and the Guidelines for the Preparation of Sustainability Reports by Listed Companies have been issued. Under the dual drive of regulation and the market, ESG is profoundly reshaping the competitive landscape of enterprises.

At the same time, scientific and technological innovation has been established as the core driving force of high-quality development. A large number of studies have found that ESG performance can promote corporate innovation. Fang Xianming and Hu Ding pointed out that ESG advantages promote innovation by alleviating financing constraints and improving governance efficiency [1].

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Xie Hongjun and Lü Xue, from the perspective of outward direct investment, revealed how ESG performance helps enterprises obtain strategic resources by building a responsible international image [2].

However, the above studies focus on the impact of ESG on focal enterprises themselves. In fact, enterprises are embedded in supply chains, and supply chains are carriers for the cross-enterprise diffusion of knowledge and technology. Existing studies show that customer behavior affects suppliers: Dai et al. found that customers with a strong sense of social responsibility can promote suppliers to improve their social responsibility performance [3]; Jing et al. pointed out that customers' environmental regulation forces suppliers to carry out green innovation [4]; Yan Bing et al. found that enterprises' ESG green innovation spills over along the supply chain [5].

It should be noted that there are essential differences between the upstream and downstream of the supply chain in terms of information flow, power structure, and incentive mechanisms (Wang & Shin; Wong & Ngai). The ESG transmission effect may be asymmetrically distributed, but existing studies lack systematic comparison, and the understanding of the transmission mechanism still remains at the level of whether transmission exists [6, 7]. Against the background of deep integration of global value chains and the networking of industrial innovation, the "ripple effect" of corporate behavior has major economic consequences [8]. Therefore, the core questions of this paper are: Can the ESG performance of focal enterprises be transmitted to the innovation decisions of the upstream and downstream of the supply chain? Are there differences between the upstream and downstream? What is the formation mechanism? Answering these questions is of great significance for improving supply chain ESG governance and promoting collaborative innovation.

In response to the above theoretical and practical gaps, this paper focuses on how the ESG performance of midstream enterprises is transmitted along the upstream and downstream of the supply chain to the innovation activities of partner enterprises, and examines whether asymmetric characteristics exist. We take Chinese A-share listed companies from 2007 to 2024 as the research sample, use manually matched data of the top five suppliers and customers, construct a paired panel dataset of focal enterprises and supply chain partners, and conduct empirical analysis using a two-way fixed effects model. The study finds that ESG performance significantly increases the R&D investment of downstream customer enterprises, but has no significant impact on upstream suppliers. Further mechanism tests show that upstream-downstream differences in information transmission channels such as market power and analyst attention are important reasons for the asymmetry. This paper systematically reveals for the first time the asymmetric innovation spillover effect of ESG performance in the supply chain, enriches the literature in the intersecting field of corporate social responsibility and supply chain management, and provides micro-level evidence for the differentiated policy design of enterprises with different property-rights characteristics and industry attributes.

The marginal contributions of this paper are reflected in the following aspects. First, it expands the research perspective. Instead of focusing on the impact of ESG on a single enterprise itself, it extends ESG research from the supply chain perspective to the level of cross-enterprise innovation transmission, reveals the transmission of ESG performance as a non-financial information signal in the supply chain, and enriches the research boundary of the literature on the economic consequences of ESG. Second, it reveals asymmetry. This paper systematically compares the asymmetry of the ESG transmission effect between the upstream and downstream of the supply chain. Existing studies mostly focus on one-way spillover, and few conduct two-way comparison within the same framework. This paper provides a theoretical explanation from the perspective of the power structure of the industrial chain and fills the gap in comparative research on upstream-downstream

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asymmetry. Third, it expands mechanism analysis. By testing the two channels of market power and analyst attention, this paper reveals the logic of the asymmetric transmission of ESG in the supply chain and advances existing literature in terms of the systematicness of mechanism identification and theoretical depth.

2. Theoretical analysis and research hypotheses

2.1. Theoretical analysis

2.1.1. Signaling theory

According to Spence's signaling theory, enterprises can alleviate information asymmetry by releasing credible signals. The improvement of the ESG performance of focal enterprises is itself a signal about responsibility and sustainable development [9]. After supply chain partners receive this signal, they will accordingly take innovation actions. Specifically, ESG improvement will prompt focal enterprises to put forward higher standards and requirements for downstream customers, urge them to follow stricter environmental protection and social responsibility criteria, and adopt more advanced production processes, thereby promoting all-round innovation among downstream customers. At the same time, the focal enterprise's demand for new products or new services also forces downstream customers to increase R&D investment. However, upstream suppliers do not directly contact the end market, have a relatively low evaluation of the value of ESG signals, and their innovation capabilities are constrained by long-term factors, so they are more inclined toward compliance-based improvement rather than fundamental innovation.

2.1.2. Resource dependence theory

Pfeffer and Salancik pointed out that the interdependence structure among organizations determines the pattern in which they exert influence on one another [10]. In the supply chain, downstream customers usually rely more on the product supply and technical standards of focal enterprises, while focal enterprises have stronger substitutability of resources on the upstream side. Therefore, downstream customers have a stronger motivation to respond to ESG signals and tend to maintain strategic matching with high-ESG enterprises by improving their innovation capabilities. However, because upstream suppliers have a diversified customer structure, the signal of a single focal enterprise has limited weight in their decision-making.

2.1.3. Stakeholder theory

Freeman believes that the survival and development of enterprises depend on the effective management of multiple demands in stakeholder networks. Miao et al. and Di & Kostovetsky summarized six types of stakeholders [11, 12]. The improvement of ESG performance reflects an enterprise's commitment to the environment, society, and governance. This commitment will transmit expectations for high-level ESG practices along the supply chain, and partners will actively respond in order to maintain business relationships [13, 14]. With the mainstreaming of ESG, downstream customers face ESG compliance pressure from the end market and can obtain marginal benefits from stable supply, reduced risks, and enhanced brand reputation. However, the compliance pressure of upstream suppliers mainly comes from the procurement side, and the cost savings brought by their technological improvements may be obtained by midstream enterprises through price pressure, leading to a mismatch between innovation returns and risks.

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The core hypothesis of this paper is as follows.

Hypothesis 1: The promoting effect of focal enterprises' ESG performance on the innovation of downstream customers is significantly stronger than its effect on upstream suppliers, and the supply chain transmission of ESG has significant upstream-downstream asymmetry.

2.2. Mechanism analysis

This paper constructs a multi-level theoretical hypothesis framework to analyze the action mechanism of asymmetric innovation transmission.

2.2.1. Market power channel

Market power, measured by HHI, is the basis for enterprises to exert pressure on the supply chain and promote innovation transmission [15]. Enterprises with high ESG performance can establish market barriers through green certification and sustainable brands, enhance their bargaining power over downstream parties, and effectively transmit innovation requirements [16]. However, in the upstream, ESG improvement may weaken the market concentration of focal enterprises through diversified procurement strategies, thereby reducing their ability to exert innovation pressure on upstream suppliers.

2.2.2. Information intermediary channel

Analysts play the role of information intermediaries. High-quality analyst coverage can reduce information asymmetry, improve enterprise visibility, and indirectly promote innovation [17]. The research focus of analysts is concentrated on end-market participants, and their ESG reports and innovation evaluations are more easily obtained and used by downstream customers, thus playing the roles of information amplification and signal verification. Upstream suppliers are usually not the objects of analyst attention, so the information intermediary role is very limited [18].

Accordingly, this paper proposes the following mechanism hypotheses.

Hypothesis 2a: Market power plays a positive mediating role in the path through which focal enterprises' ESG performance affects downstream customer innovation, while the transmission effect on the upstream supplier side may be in the opposite direction.

Hypothesis 2b: Analyst attention plays a positive information intermediary role in the transmission of focal enterprises' ESG performance to downstream customer innovation, while its transmission effect on upstream suppliers is not significant.

3. Empirical research design

3.1. Sample selection and data sources

This paper selects Chinese A-share listed companies from 2007 to 2024 as the research sample and constructs a matched panel dataset of focal enterprises and their upstream and downstream supply chain partners. The supply chain relationship data come from the Chinese Research Data Services Platform (CNRDS); ESG ratings are taken from the Huazheng ESG Rating Database; and firm-level financial data mainly come from the China Stock Market & Accounting Research (CSMAR) database.

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This paper processes the sample as follows: (1) listed companies in the financial industry are excluded; (2) companies with financial abnormalities such as ST and *ST are excluded; (3) observations with missing values in core variables are excluded; (4) samples that do not disclose key information in detail, such as the names of the top five suppliers and customers, are excluded; and (5) all continuous variables are winsorized at the 1% and 99% quantiles to eliminate the influence of extreme values. To avoid directional confusion and the problem of missing data for non-listed companies, after manual matching, the sample is split into two subsamples: one is the listed company–customer paired sample, with a total of 1,913 firm-year observations obtained; the other is the listed company–supplier paired sample, with a total of 1,178 firm-year observations obtained. The specific measurement methods of the main variables are shown in Table 1.

Table 1. Variable settings

Variable Type	Variable Symbol	Variable Name	Measurement Method
Dependent variable	*RD*	Innovation input	R&D expenditure of supply chain partner / total assets
Explanatory variable	*ESG*	Corporate ESG performance	Huazheng ESG rating converted into a numerical value and then taking the logarithm
Control variable	*Size*	Enterprise size	Natural logarithm of annual total assets
	Growth	Operating revenue growth rate	Operating revenue of the current year / operating revenue of the previous year − 1
	Lev	Asset-liability ratio	Total liabilities at year-end / total assets at year-end
	ROA	Return on total assets	Net profit / total assets
	Fixed	Fixed asset ratio	Net fixed assets / total assets
	Intangible	Intangible asset ratio	Net intangible assets / total assets
	Dual	Duality of two positions	Takes the value of 1 if the chairman and general manager are the same person, and 0 otherwise

3.2. Variable settings

Dependent variable. This paper uses the ratio of R&D expenditure of supply chain partners to total assets (RD) to measure the intensity of innovation input, which serves as an embodiment of enterprise innovation capability. R&D input can better reflect an enterprise's current substantive innovation efforts and is not disturbed by strategic behavior in patent applications [19].

Explanatory variable. Referring to the studies of Fang Xianming et al. and Xie Hongjun et al., this paper uses Huazheng ESG rating data as the proxy variable for corporate ESG performance. The Huazheng ESG ratings, which range from C to AAA and include a total of nine levels, are converted into continuous values from 1 to 9, and after taking the annual mean, 1 is added and the natural logarithm is taken [1, 2].

Control variables. To exclude the interference of the characteristics of focal enterprises themselves and those of supply chain partners on the regression results, with reference to Mahmut et al. [20] and Yan Bing [5], this paper simultaneously controls for enterprise size (Size), operating revenue growth rate (Growth), asset-liability ratio (Lev), return on total assets (ROA), fixed asset ratio (Fixed), intangible asset ratio (Intangible), and duality of two positions (Dual) at the levels of both focal enterprises and supply chain partners. Customer-side variables are prefixed with "g," and supplier-side variables are prefixed with "s."

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3.3. Model construction

This study adopts a two-way fixed effects regression model:

$$RD_{it}^{j} = \beta_0 + \beta_1 \cdot ESG_{it} + +\gamma \cdot Controls_{it} + \mu_i + \lambda_t + \delta_s + \varepsilon_{it}$$

where the subscripts i、j、t represent the focal enterprise, the supply chain partner enterprise, and the year, respectively. RD_{it}^{j} is the R&D input intensity of the customer or supplier enterprise; ESG_{it} represents the current ESG performance of the focal enterprise; $Controls_{it}$ is a vector of a series of control variables of the focal enterprise and the supply chain partner. μ_i , λ_t , δ_s are enterprise, year, and industry fixed effects, respectively, and ε_{it} is the random disturbance term. Finally, the standard errors are clustered at the midstream enterprise level. The core coefficient of this paper is β_1 , which reflects the impact of the ESG performance of focal enterprises on the innovation activities of supply chain partners.

4. Analysis of empirical result

4.1. Benchmark regression results

Table 2 reports the benchmark regression results. Columns (1) to (3) show the impact of focal enterprises' ESG on downstream customer innovation. When only enterprise fixed effects are controlled, the ESG coefficient is 0.0201 and is significant at the 10% level. After year fixed effects are added, it rises to 0.0226 and is significant at the 5% level. After industry fixed effects are further controlled, it rises to 0.0256 and is significant at the 1% level, indicating that for every 1% increase in ESG performance, customer innovation capability, measured by the ratio of R&D investment to total assets, increases by an average of about 2.56 percentage points. Columns (4) to (6) show that, regardless of which fixed effects are controlled, the impact of ESG on upstream supplier innovation is not significant. We find that the ESG performance of focal enterprises significantly promotes downstream customer innovation, but has no significant impact on upstream suppliers, presenting a clear asymmetric pattern.

Table 2. Benchmark regression

	(1)	(2)	(3)	(4)	(5)	(6)
	g_RD	g_RD	g_RD	s_RD	s_RD	s_RD
ESG	0.0201*	0.0226**	0.0256***	0.0185	0.0161	0.0124
	(0.0106)	(0.0088)	(0.0089)	(0.0158)	(0.0144)	(0.0148)
_cons	-0.1650**	-0.0066	-0.0269	-0.1386	0.1220	0.1105
	(0.0680)	(0.0557)	(0.0606)	(0.0869)	(0.1133)	(0.1203)
Control variables	YES	YES	YES	YES	YES	YES
Enterprise fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	NO	YES	YES	NO	YES	YES

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Table 2. (continued)

Industry fixed effects	NO	NO	YES	NO	NO	YES
N	1371	1371	1368	791	791	791
R^2	0.7844	0.8049	0.8085	0.6780	0.7016	0.7114
adj. R^2	0.7101	0.7338	0.7250	0.5441	0.5658	0.5430

4.2. Treatment of endogeneity problems

4.2.1. Reverse causality

Customer enterprises with stronger innovation capability are more inclined to cooperate with midstream enterprises with excellent ESG performance. Column (1) of Table 3 takes ESG as the dependent variable and customer innovation capability (g_RD) as the core explanatory variable for regression. The results show that the coefficient of g_RD is 0.4389, which is significantly positive at the 5% level, indicating that this study may have a reverse causality problem.

4.2.2. 2SLS instrumental variable method

The mean ESG value of other enterprises in the same industry is selected as the instrumental variable, and two-stage least squares estimation is conducted. Columns (2)–(3) of Table 3 report the regression results. In the first-stage regression, the coefficient of the instrumental variable is significantly positive at the 1% level, confirming strong correlation. In the second-stage regression, the ESG coefficient is 0.0215 and is significant at the 10% level, indicating that the results are robust.

4.2.3. Propensity score matching estimation

To alleviate the potential endogeneity problem caused by systematic differences in control variables between economically developed regions and underdeveloped regions, enterprises registered in Beijing, Shanghai, and Guangdong are taken as the treatment group, and 1:4 nearest-neighbor matching with a caliper of 0.01 is adopted for PSM estimation. The regression results are shown in column (4) of Table 3. The ESG coefficient is 0.0299 and is significant at the 10% level, which is highly consistent with the benchmark conclusion.

Table 3. Endogeneity test

	(1)	(2)	(3)	(4)
	ESG	IV first stage	IV second stage	PSM matched sample
g_RD	0.4389**			
	(0.1730)			
mean		0.0630***		
		(0.0023)		
ESG			0.0215*	0.0299*
			(0.0120)	(0.0159)

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Table 3. (continued)

_cons	3.9196***	3.8609***		-0.1011
	(0.3184)	(0.0392)		(0.0938)
Control variables	Yes	Yes	Yes	Yes
Enterprise fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
N	1368	1618	1371	
R^2	0.7514	0.6451	0.0967	
adj. R^2	0.6430	0.6384	0.0765	

4.3. Robustness test

4.3.1. Controlling high-dimensional fixed effects

To absorb unobservable time-varying confounding factors as much as possible, this paper conducts tests by replacing high-dimensional fixed effects and reports the regression results in Table 6. Column (1) controls enterprise, year, and industry × year fixed effects. Column (2) controls enterprise, year, and province × year fixed effects. Column (3) controls enterprise, year, industry × year fixed effects, and province × year fixed effects, and the clustering method is the same as that of the benchmark regression. The results show that under all settings, the coefficients remain positively significant at least at the 10% level, and the core conclusion of this paper has not changed.

4.3.2. Changing the clustering level of standard errors

This paper further relaxes the clustering assumption by aggregating standard errors at a higher level as a robustness check. Column (4) of Table 4 raises the clustering level to the industry level, and the fixed effects are the same as those in the benchmark regression. After adopting industry-level clustered standard errors, neither the coefficient size nor the significance level changes substantially, indicating that the benchmark conclusion is not sensitive to the clustering method of standard errors.

Table 4. Robustness test

	(1)	(2)	(3)	(4)
	g_RD	g_RD	g_RD	g_RD
ESG	0.0176*	0.0393***	0.0723**	0.0256***
	(0.0095)	(0.0138)	(0.0325)	(0.0075)
_cons	-0.0793	-0.0563	-0.1882	-0.0269
	(0.0727)	(0.0920)	(0.1645)	(0.0613)
Control variables	Yes	Yes	Yes	Yes
Enterprise fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

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Table 4. (continued)

Industry fixed effects	No	No	No	Yes
Industry × year fixed effects	Yes	No	Yes	No
Province × year fixed effects	No	Yes	Yes	No
Enterprise-level clustering	Yes	Yes	Yes	No
Industry-level clustering	No	No	No	Yes
N	1205	1264	1111	1368
R^2	0.8769	0.8472	0.9072	0.8085
adj. R^2	0.7719	0.7179	0.7610	0.7250

4.4. Mechanism test

4.4.1. Market power

This paper uses the Herfindahl-Hirschman Index (HHI) of the industry in which the midstream enterprise is located to measure market power, and tests the impact of ESG performance on it as well as the upstream-downstream differences. To avoid the estimation bias of traditional mediation effects (Jiang Ting) [21], we use the following function for detailed testing:

$$Mediator_{it} = \beta_0 + \beta_1 \cdot ESG_{it} + +\gamma \cdot Controls_{it} + \mu_i + \lambda_t + \delta_s + \varepsilon_{it}$$

The results in columns (3) and (4) of Table 5 show that, on the customer side, the ESG coefficient is significantly positive at the 10% level, indicating that the better the ESG performance of an enterprise, the higher its market concentration, and the stronger its bargaining and standard-setting capabilities over downstream parties, thereby more effectively promoting customer innovation upgrading. On the supplier side, the ESG coefficient is significantly negative at the 10% level, indicating that ESG instead weakens the market power of midstream enterprises over the upstream. That is, enterprises with higher ESG are in a more dispersed market competition pattern and lack the ability to exert pressure on the upstream. Suppliers facing multiple customers do not need to adjust their innovation strategies for a single ESG standard.

4.4.2. Analyst attention

Information asymmetry is an important obstacle that makes it difficult for ESG to effectively spill over. As information intermediaries, analysts can alleviate information asymmetry and promote innovation [22, 23]. This paper uses the natural logarithm of the number of analyst followings to proxy analyst attention. Columns (3) and (4) of Table 5 show that, on the customer side, the ESG coefficient is positively significant at the 5% level, indicating that enterprises with higher ESG performance receive stronger analyst attention, which helps transmit signals to downstream parties. On the supplier side, the coefficient is positive but not significant. This indicates that the information intermediary mechanism of analyst attention mainly acts on the downstream side, while the upstream transmission path is blocked, providing empirical support at the information level for the

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asymmetry of ESG spillover effects. This finding is consistent with the study by Du Yong et al. on common analysts in supply chains: the tracking by common analysts usually takes core enterprises close to the end market as the hub. After the analyst attention of focal enterprises themselves increases, it will indirectly benefit downstream customers through the knowledge spillover of common analysts and promote downstream innovation [24].

Table 5. Mechanism analysis

	(1)	(2)	(3)	(4)
	HHI	HHI	Analyst attention	Analyst attention
ESG	0.0870*	-0.0434*	1.1602**	0.6834
	(0.0468)	(0.0248)	(0.5038)	(0.7112)
_cons	-0.5840*	0.3884**	-12.2204***	-12.1017***
	(0.3178)	(0.1542)	(3.6594)	(4.6051)
Control variables	YES	YES	YES	YES
Enterprise fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES
N	1368	791	1368	791
R^2	0.9615	0.9706	0.8744	0.8274
adj. R^2	0.9447	0.9535	0.8196	0.7267

4.5. Heterogeneity analysis

4.5.1. Heterogeneity analysis based on high-tech industry matching

The degree of high-tech industry matching between focal enterprises and customers determines the knowledge base and absorptive capacity of both parties, thereby affecting the transmission efficiency of ESG spillover effects. Drawing on the classification method of Peng Hongxing et al. [25], enterprises are divided into high-tech industries and non-high-tech industries, and are divided into three groups according to whether both parties belong to high-tech industries. Column (1) of Table 6 shows that when both parties are in high-tech industries, the ESG coefficient is 0.0241 and is significant at the 5% level. Column (2) shows that when one party is in a high-tech industry, the coefficient is 0.0242 and is significant at the 5% level. Column (3) shows that when both parties are in non-high-tech industries, the coefficient is negative and not significant. This indicates that the participation of high-tech industries is an important prerequisite for ESG information to be effectively transformed into innovation motivation. Non-high-tech industries, due to weak knowledge bases and insufficient absorptive capacity, cannot form effective innovation incentives.

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4.5.2. Heterogeneity analysis based on equity nature matching

Enterprise equity characteristics also affect the ESG transmission effect [26]. This paper divides enterprises into state-owned and non-state-owned according to the proportion of state-owned capital, and conducts grouped regressions according to the combination of property-rights nature of focal enterprises and customers. Columns (4) and (5) of Table 6 show that when both parties are state-owned enterprises or when one party is state-owned and the other party is non-state-owned, the ESG coefficients are negative and not significant. Column (6) shows that when both parties are non-state-owned enterprises, the coefficient is 0.0421 and is significant at the 1% level. A possible explanation is that non-state-owned enterprises are more sensitive to market signals, and ESG performance is directly related to their financing, reputation, and customer relationships, so their response elasticity is higher. In supply chains involving state-owned enterprises, factors such as government intervention and soft budget constraints interfere with the market-oriented signal transmission path, making it difficult for the market value of ESG to be transmitted smoothly.

Table 6. Heterogeneity test

	(1)	(2)	(3)	(4)	(5)	(6)
	g_RD	g_RD	g_RD	s_RD	s_RD	s_RD
ESG	0.0241**	0.0242**	-0.0023	-0.0036	0.0011	0.0421***
	(0.0116)	(0.0093)	(0.0136)	(0.0152)	(0.0119)	(0.0139)
_cons	-0.0341	-0.0270	0.2638**	-0.0640	0.0570	-0.0858
	(0.1012)	(0.0599)	(0.1223)	(0.1150)	(0.0866)	(0.1191)
Control variables	YES	YES	YES	YES	YES	YES
Enterprise fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Industry fixed effects	YES	YES	YES	YES	YES	YES
N	732	613	202	404	502	401
R^2	0.8281	0.8268	0.9253	0.8586	0.8541	0.9154
adj. R^2	0.7540	0.7150	0.8254	0.7721	0.7547	0.8389

5. Research conclusions and implications

Based on the above empirical analysis, this paper draws the following core findings and policy implications. First, this paper confirms that ESG performance has an asymmetric innovation spillover effect characterized by “downward transmission and upward failure”: for every 1% increase in the ESG performance of focal enterprises, the R&D investment intensity of downstream customers increases by an average of about 2.56 percentage points, while its impact on upstream suppliers remains insignificant. This conclusion remains robust after endogeneity treatment, high-dimensional fixed effect control, and PSM matching. Second, the mechanism test reveals that the enhancement of market power and the increase in analyst attention serve as effective transmission channels only on the downstream side, while transmission on the upstream side is blocked due to information asymmetry and a decentralized market structure. Third, the heterogeneity analysis shows that in scenarios involving non-state-owned enterprises and at least one party belonging to a high-tech industry, the innovation-driving role of ESG is more prominent, whereas state-owned

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attributes significantly weaken this effect. This paper provides new evidence for understanding the supply chain spillover effect of ESG and has policy implications for guiding enterprises' green transformation and innovation collaboration.

Based on the above research findings, this paper proposes the following policy recommendations.

First, focus on the transmission advantages of the downstream supply chain and improve targeted incentive policies for the coordination of ESG and innovation. A green innovation linkage support system for core enterprises and downstream customers should be established. Through tools such as special subsidies, tax incentives, and green credit, core enterprises should be encouraged to transform ESG performance into transmissible and implementable innovation standards and cooperation requirements, so as to guide downstream customers to simultaneously improve their R&D investment and green transformation level, and form a stable and sustainable supply chain innovation spillover mechanism.

Second, implement industry-differentiated support and strengthen the leading role of high-tech industries in ESG innovation transmission. Policy support for high-tech industry supply chains should be increased, supporting them in giving play to their advantages in knowledge bases and absorptive capacity and driving supply chain partners to carry out joint research and development of green technologies. At the same time, technical connection, knowledge sharing, and capacity-building services should be provided for non-high-tech industries, so as to improve the overall innovation absorption level of industries and realize the coordinated improvement of innovation capability across the entire industrial chain.

Third, optimize the market-oriented mechanisms of entities with different property-rights attributes and fully release the vitality of ESG innovation transmission among private enterprises. The ESG incentive and constraint mechanisms for private supply chains should be improved, and market-oriented transmission paths such as financing, reputation, and customer relationships should be smoothed. At the same time, state-owned enterprises should be promoted to deepen market-oriented reform, weaken soft budget constraints and non-market-oriented intervention, improve the response efficiency of state-owned enterprises to ESG signals, and promote entities with different property-rights attributes to make coordinated efforts in the supply chain, jointly releasing the driving value of ESG performance for enterprise innovation.

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