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Study on the Impact of ESG Investment on Corporate Carbon Intensity

Lishu Zhu*

School of Finance, Anhui University of Finance and Economics, Bengbu, China

*Corresponding Author

Abstract

With the growing emphasis on sustainable development goals globally, Environmental, Social, and Governance (ESG) investment has gradually become a key indicator for evaluating corporate sustainability. This paper selects A-share listed companies in China from 2011 to 2022 as the research sample to empirically examine the impact of ESG investment on corporate carbon intensity and its mechanisms. The study finds that ESG investment and its three components can significantly reduce corporate carbon intensity, and this conclusion remains robust even after addressing endogeneity issues. Heterogeneity analysis shows that ESG investment significantly reduces carbon intensity in non-labor-intensive enterprises. Mechanism analysis reveals that ESG investment lowers corporate carbon intensity through two channels: improving asset turnover and reducing operating expense ratios. Finally, a series of policy recommendations are proposed based on the above conclusions.

Keywords

ESG Investment; Carbon Intensity; Asset Turnover; Operating Expenses.

1. Introduction

Reducing carbon intensity is the primary goal faced by the world. Many initiatives have been proposed to encourage sustainable development and reduce the dependence on fossil fuels (Zou et al., 2023)[1]. At the 28th Conference of the Parties (COP28), countries put forward a series of approaches to reduce carbon intensity and pledged to reduce the expansion of fossil fuels to promote the achievement of carbon neutrality (Lokmic-Tomkins et al., 2024)[2]. To address the increasingly severe environmental problems, the Chinese government has successfully introduced a series of environmental regulatory policies. The Third Plenary Session of the 20th Central Committee of the Communist Party of China pointed out that "a new mechanism for the comprehensive transformation from the dual control of energy consumption to the dual control of carbon emissions should be established" and that "after reaching the carbon peak, a dual control system for carbon emissions, with total amount control as the main approach and intensity control as the supplementary approach, should be implemented". Facing compliance pressure, enterprises have to increase their green investments, and certain results have been achieved in carbon emission reduction (Huang et al., 2023)[3]. However, due to the frequent inconsistency between the goals of the central and local governments in terms of environmental protection and economic development (Xie et al., 2016)[4], the formal implementation of environmental regulatory policies faces the dilemma of "active government, passive enterprises, and inactive public" in the "top-down" process. This leads to the situation where specific policies are either difficult to effectively implement during the implementation process, or lack sufficient implementation and enforcement efforts, or the implementation results are overly rigid and uniform, resulting in high costs and low efficiency, and making it difficult to achieve the expected governance outcomes (Han et al., 2023)[5].

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China's environmental governance practices have shown that if administrative measures such as fines, closures, and rectifications are adopted to passively force enterprises to reduce their carbon emission intensity, it will not only cause economic losses and damage the vitality of enterprises but also be detrimental to industrial development and the stable operation of the economy. Enterprises' carbon reduction actions may also be short-term and repetitive, greatly reducing the policy effectiveness of environmental regulations (Wang et al., 2023)[6]. In addition, this greatly increases the difficulty of government supervision, raises governance costs, and leads to a decline in social welfare. Existing research shows that overly strict environmental regulations by the government will increase the production costs of enterprises, reduce total factor productivity (Wu et al., 2020)[7], and affect innovation capabilities (Zhao and Sun, 2016)[8], thus reducing international competitiveness. Compared with environmental regulations that require enterprises to participate in carbon reduction by force, the "invisible hand" of the market has formed informal environmental regulations with the characteristics of "bottom-up" governance. It plays an increasingly important role in environmental governance, better stimulates enterprises' motivation for carbon reduction, and achieves green and low-carbon development. Fichtner et al. (2024)[9] pointed out that environmental, social, and governance (ESG) investment is an indispensable factor in improving the efficiency and sustainability of natural capital stock. ESG investment involves environmental, social, and governance support for the natural capital stock to promote the sustainable development of natural capital (Zou et al., 2023)[1]. From the perspective of the ecosystem, ESG investment reflects the importance of the efficiency of natural capital stock for reducing carbon intensity (Foley et al., 2024)[10]. From the perspective of natural resources, Sang et al. (2024)[11] also confirmed this finding, pointing out that ESG investment is crucial for the protection of natural resources. However, this research mainly uses an overall approach to explore the impact of ESG investment on carbon intensity from the perspective of natural capital accounting.

Compared with existing literature, the marginal contributions of this study mainly lie in: (1) In terms of research content, this paper studies the impact of ESG investment on the carbon intensity of Chinese listed enterprises, expanding the research perspectives on ESG investment and the governance of enterprise carbon intensity. (2) In terms of the impact mechanism, this paper incorporates ESG investment and enterprise carbon intensity into the same analysis framework, supplementing the impact mechanism of ESG investment on improving enterprise carbon intensity. Specifically, it analyzes the action mechanism of ESG investment on enterprise carbon intensity from two channels: asset turnover and operating expenses.

2. Theoretical Analysis and Research Hypotheses

2.1. ESG Investment and Enterprise Carbon Intensity

ESG investment refers to fully considering environmental, social, and corporate governance factors in investment decisions, aiming to reduce the investment risks of the principal entity and promote the sustainable development of society. In recent years, an increasing number of studies have focused on the role played by ESG investment under the "dual carbon" goals. From the perspective of resource utilization, the theory of resource utilization efficiency emphasizes that during the production and operation processes, enterprises need to maximize the efficiency of resource use to reduce waste. ESG investment incentivizes enterprises to implement environmental protection measures and improve their resource management levels (Jiang et al., 2023)[12]. For example, it can optimize production processes, and improve the efficiency of equipment and facility usage. By introducing more efficient production technologies and management systems, enterprises can reduce the carbon emission intensity per unit of output, and thus lower the overall carbon intensity (Xie, 2024)[13]. Therefore, ESG investment can, by promoting enterprises to improve the efficiency of resource utilization,

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reduce their carbon emission levels and provide the possibility of reducing their carbon emission intensity. From the perspective of technological innovation, technological innovation is a key and effective driving force for enhancing the sustainable development of enterprises (Yuan and Zhang, 2020)[14]. ESG investment usually prompts enterprises to increase their investment in the development of new technologies (Gao et al., 2025)[15], especially in the fields of renewable energy and energy conservation and emission reduction technologies (Huang et al., 2024) [16]. Through the research, development, and application of green technologies, enterprises can significantly reduce the carbon emissions generated during the production process. For example, many enterprises invest resources in developing biofuels and using alternative energy sources such as solar energy. These measures not only help to reduce carbon intensity but also contribute to enterprises' long-term economic benefits. Therefore, technological innovation has established a direct and positive connection between ESG investment and enterprise carbon intensity. From the perspective of the external environment and market pressure, in recent years, consumers and investors have shown increasing concern for the sustainable development of enterprises, which has led to greater pressure on enterprises from the external environment and the market (Liu et al., 2024)[17]. ESG investment not only reflects the preferences of the sources of funds but also conveys society's expectations for enterprises' environmental responsibilities. In this situation, to maintain their competitive advantages and meet social expectations, enterprises often need to take measures to reduce their carbon emission intensity (Liu and Li, 2025) [18]. This external pressure will prompt enterprises to take more proactive environmental protection actions, thus affecting their performance in terms of carbon intensity. From the perspective of the stakeholder theory, the stakeholder theory mainly emphasizes that the success of an enterprise depends not only on the interests of shareholders but also on the consideration of other stakeholders (Saka-Helmhout et al., 2024)[19], such as employees, customers, suppliers, and the general public. ESG investment incorporates the requirements of these stakeholders into corporate decision-making, promoting enterprises to pay attention to environmental and social responsibilities (Liu., 2025)[20]. By enhancing the awareness and management of environmental issues (Deng et al., 2024)[21], enterprises can formulate emission reduction strategies more effectively, thereby reducing carbon intensity. Research shows that meeting the expectations of stakeholders can not only enhance the social image of enterprises but also improve their market performance and long-term sustainability.

Based on the above analysis, Hypothesis H1 is proposed:

H1: ESG investment has a negative impact on the carbon intensity of enterprises.

2.2. Analysis of the Mechanism by Which ESG Investment Influences the Carbon Intensity of Enterprises

2.2.1. Asset Turnover

The asset turnover ratio refers to the efficiency with which a company's assets generate operating revenue within a certain period. Effective asset turnover means that when a company utilizes its assets, it can achieve higher economic and environmental benefits. ESG investment encourages companies to focus on the efficient utilization of equipment and resources, thereby improving the asset turnover ratio. In terms of optimizing resource allocation, when a company accepts ESG investment, it often optimizes and integrates its resource allocation. This can not only improve production efficiency but also reduce resource waste (Tan et al., 2024)[22]. In the process of optimizing resource utilization, companies can reduce the carbon emission intensity in the production process (Xiao et al., 2024)[23]. This approach of reducing carbon intensity by increasing the asset turnover ratio demonstrates the direct relationship between resource use efficiency and environmental performance. As the asset turnover ratio increases, companies can produce more products with fewer resources and in less time. This improvement in

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efficiency means that the carbon emissions per unit of product will decrease. Improving the asset turnover ratio is usually accompanied by the optimization of inventory management. A higher turnover ratio means that companies need to maintain a lower inventory level, which can significantly reduce material waste. Reducing inventory and waste not only optimizes the use of resources but also reduces the associated carbon emission intensity. When a company can convert materials into products more quickly, its environmental impact is correspondingly reduced. Therefore, Hypothesis H2 is proposed:

H2: ESG investment reduces the carbon intensity of enterprises by increasing the total asset turnover ratio.

2.2.2. Operating Expenses

Operating expenses refer to various expenditures incurred by an enterprise during its daily operation process, including material costs, employee salaries, energy expenses, etc. To a certain extent, ESG investment will prompt enterprises to re-evaluate and manage their operating expenses. Li and Cheng (2024)[24] believe that ESG investment helps to reduce the transaction costs of enterprises. Investing in ESG also means that enterprises need to adopt a series of measures for energy conservation and emission reduction. For example, enterprises can reduce energy expenses by improving production processes, using alternative energy sources, optimizing logistics, and other means. These measures not only reduce operating costs but also effectively reduce the carbon emissions of enterprises, thus having a positive impact on carbon intensity. With the increasing strictness of environmental regulations, the operating expenses of enterprises in terms of compliance are constantly increasing. To meet ESG standards, enterprises may need to invest more resources in environmental protection facilities and management. However, through these investments, enterprises can achieve a lower carbon intensity in the long run. Therefore, although operating expenses may increase in the short term, in the long run, such investments will help enterprises optimize resource allocation and reduce carbon emissions per unit of output. ESG investment can prompt enterprises to attach importance to the selection and use of materials. For example, enterprises can reduce waste and raw material consumption through refined management and optimized production design, thereby reducing carbon emissions during the production process. The improvement of material use efficiency can not only reduce the expenditure of enterprises on materials but also help to lower their overall carbon intensity. Therefore, Hypothesis H3 is proposed:

H3: ESG investment reduces the carbon intensity of enterprises by decreasing the operating expense ratio.

ESG investment forms a synergistic cycle through the dual mechanisms of asset turnover and operating expenses. On the one hand, increasing the asset turnover ratio makes enterprises more efficient in resource utilization, thereby reducing the carbon emission intensity of enterprises. On the other hand, by optimizing operating expenses, enterprises can reduce costs during the production and operation processes while achieving environmental protection goals. These two aspects complement each other in this process, enabling enterprises to find a balance between economic benefits and environmental performance, and thus enhancing their long-term sustainability. When formulating their ESG investment strategies, enterprises should systematically consider the interaction mechanisms of these two aspects to achieve lower carbon intensity and higher sustainable development goals.

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3. Research Design

3.1. Data

This study selects companies listed on China's Shanghai and Shenzhen A-shares between 2011 and 2022 as the samples. The data are sourced from the CSMAR database and the WIND database, and the ESG rating data also come from the WIND database. The data on the total energy consumption and operating costs of the industries are referenced from the China Energy Statistical Yearbook and the China Industrial Statistical Yearbook. During the data screening process, the following principles are followed: (1) Exclude the data of the financial industry; (2) Exclude companies whose trading statuses are ST and ST* in that year; (3) Exclude companies with missing key data. Finally, this study obtains 24,371 firm-year sample observations. To reduce the impact of outliers on the empirical results, all continuous variables are winsorized at the top and bottom 1%.

3.2. Variable Explanation

Explained variable: Enterprise carbon intensity, that is, the carbon emission intensity of the enterprise. According to Chapple et al. (2013)[25], the carbon emission reduction intensity of the enterprise is measured by dividing the carbon dioxide emissions of the enterprise by its operating revenue. The calculation formula is shown in Equation(1).

$$\text{intensity}=\frac{\text{Carbon dioxide emissions}}{\text{Revenue from Principal Business}\times 1000000} \quad (1)$$

Core explanatory variable: ESG investment (ESG). The ESG rating data mainly comes from third-party institutions. Among them, the Huazheng ESG rating system integrates the main international and domestic evaluation frameworks, has a wide coverage, and is updated relatively promptly. Therefore, this paper selects the Huazheng ESG rating as the performance of enterprises' ESG investment, and uses three first-level indicators in its rating indicators, namely Environment (E), Society (S), and Corporate Governance (G), to conduct a detailed analysis of their impact on the carbon intensity of enterprises. The scoring method is adopted for the rating results. The nine rating levels from "AAA" to "C" are assigned scores from 9 to 1 in sequence. The higher the score, the better the rating.

The definitions of control variables are as follows: (1) Enterprise nature (SOE): State-owned holding enterprises are marked as 1, and other enterprises are marked as 0; (2) Enterprise size (Size): Represented by the logarithm of total assets; (3) Asset-liability ratio (Lev): Calculated by the ratio of total liabilities to total assets; (4) Return on assets (ROA): Represented by the ratio of net profit to total assets; (5) Return on equity (ROE): Obtained by the ratio of net profit to the total amount of owners' equity; (6) Gross profit margin on sales (Gross Profit): Calculated as the ratio of the result of operating revenue minus operating costs to operating revenue; (7) Proportion of fixed assets (FIXED): Represented by the ratio of the net amount of fixed assets to total assets; (8) Dual positions (Dual): Marked as 1 when the chairman of the board and the general manager hold the same position; (9) Shareholding ratio of the largest shareholder (Top1): Represented by the shareholding ratio of the largest shareholder.

Mechanism variables include: (1) Asset turnover ratio (ATO): Calculated by the ratio of operating revenue to average total assets; (2) Operating expense ratio (Ofee): Calculated as the ratio of the sum of administrative expenses and sales expenses to operating revenue. The descriptive statistical data of each variable are shown in Table 1. The research results show that the average value of enterprises' ESG investment is 4.120, indicating that the ESG investment of listed companies still needs to be improved. In terms of carbon emission intensity, the

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maximum value is 206 and the minimum value is 0. The large difference between the maximum and minimum values reflects that there are significant differences in the carbon emission intensity levels of Chinese listed companies, indicating that enterprises still have the potential to reduce carbon intensity. The statistical characteristics of other control variables are consistent with the results of relevant literature.

Table 1. Descriptive Statistics

variable	N	mean	sd	min	max
intensity	24371	2.983	2.955	0	206.0
ESG	24371	4.120	1.066	1	8
E	24371	1.963	1.149	1	8
S	24371	4.218	1.114	1	8
G	24371	5.354	1.350	1	9
SOE	24371	0.311	0.463	0	1
Size	24371	22.14	1.265	18.97	26.89
Lev	24371	0.397	0.198	0.0533	1.145
ROA	24371	0.0436	0.0671	-0.337	0.236
ROE	24371	0.0645	0.149	-1.098	0.563
GrossProfit	24371	0.289	0.174	-0.0553	0.838
FIXED	24371	0.237	0.148	0.00161	0.722
Dual	24371	0.311	0.463	0	1
Top1	24371	34.11	14.53	8.448	74.82
Ofee	24371	0.160	0.133	0.0139	1.124
ATO	24371	0.655	0.391	0.0376	2.691

3.3. Model Design

To test the impact of ESG investment on the carbon intensity of enterprises, this paper specifies the basic econometric model as follows:

$$intensity_{it-1}=\alpha_0+\alpha_1 ESG_{it}+\alpha_2 Controls_{it}+\gamma_i+\mu_t+\varepsilon_{it} \quad (2)$$

Among them, $intensity_{it-1}$ represents the carbon intensity situation of the i enterprise in the year t - 1. The response of the enterprise's carbon intensity to ESG investment often lags, and to alleviate the endogeneity problem caused by reverse causality, the explained variable is treated with a one-period lag. ESG_{it} is the ESG rating of the i enterprise in the year t, and its coefficient α_1 represents the degree of influence of ESG investment on the carbon emission intensity of the enterprise. $Controls_{it}$ represents the set of control variables. In addition, considering the existence of unobservable variables, this paper also controls for the firm-specific (γ_i) and time (μ_t) fixed effects, and ε_{it} represents the residual term.

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4. Analysis of Empirical Results

4.1. Results of the Benchmark Regression

Table 2. Benchmark Regression Results

	(1)	(2)	(3)	(4)
	L.intensity	L.intensity	L.intensity	L.intensity
ESG	-0.160***			
	(0.028)			
E		-0.049***		
		(0.018)		
S			-0.151***	
			(0.027)	
G				-0.097***
				(0.021)
SOE	-0.255	-0.014	-0.251	-0.255
	(0.163)	(0.050)	(0.163)	(0.163)
Lev	0.329	0.325**	0.357	0.284
	(0.249)	(0.133)	(0.249)	(0.251)
Size	0.748***	0.044**	0.743***	0.723***
	(0.064)	(0.020)	(0.064)	(0.063)
ROA1	1.581**	0.290	1.636**	1.575**
	(0.731)	(0.584)	(0.731)	(0.731)
ROE	0.478*	0.556**	0.470*	0.494*
	(0.275)	(0.246)	(0.275)	(0.275)
GrossProfit	-0.765**	-0.136	-0.779**	-0.800**
	(0.380)	(0.138)	(0.380)	(0.381)
FIXED	0.848***	-0.008	0.858***	0.834**
	(0.324)	(0.142)	(0.324)	(0.324)
Dual	0.106	0.053	0.109	0.108
	(0.077)	(0.046)	(0.077)	(0.077)
Top1	0.030***	0.005***	0.029***	0.030***
	(0.004)	(0.001)	(0.004)	(0.004)
FirmAge	0.875**	-0.051	0.870**	0.878**
	(0.443)	(0.066)	(0.443)	(0.443)
Constant	-16.414***	2.271***	-16.323***	-15.992***
	(1.827)	(0.440)	(1.827)	(1.830)
Company	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	20,335	20,335	20,335	20,335

Note: L. represents a one-period lag of the variable. *** , ** , and * denote significance at the 1%, 5%, and 10% levels respectively. The standard errors are shown in parentheses.

Table 2 presents the results of the benchmark regression of the model. From Column (1), it can be seen that the coefficient of ESG is -0.160, which is significant at the 1% confidence level. There is a significant negative impact of ESG investment on carbon intensity, indicating that ESG investment can reduce the carbon emission intensity of enterprises. Thus, Hypothesis H1

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is verified. Columns (2) - (4) in Table 2 show the regression results of the random-effects model where the three first-level indicators of ESG investment, namely Environmental protection (E), Social responsibility (S), and Corporate Governance (G), replace ESG in the benchmark model. It can be observed that the coefficient of the E indicator is -0.049, significant at the 1% confidence level. This suggests that enterprises can reduce carbon intensity through environmental protection measures such as the development of green finance. The coefficient of the S indicator is -0.151 and is significant at the 1% confidence level. By training employees, formulating environmental protection measures, and implementing best practices, enterprises can enhance the awareness of energy conservation among all employees, thereby effectively reducing the waste of energy and resources in daily operations. The coefficient of the G indicator is -0.097, also significant at the 1% confidence level. A good corporate governance structure ensures that enterprises set clear sustainable development goals and carbon-reduction strategies, leading to a greater emphasis on environmental protection in management decision-making.

4.2. Robustness Test

4.2.1. Endogeneity Test

The carbon intensity of an enterprise may also, in turn, influence its ESG investment. To mitigate the potential endogeneity problem, this paper adopts the following approaches:

(1) Lag the explained variable by one period to alleviate the endogeneity issue caused by reverse causality.

Table 3. Results of the Endogeneity Test

	(1)	(2)	(3)	(4)
	ESG	L.intensity	ESG	L.intensity
iv1	0.878***			
	(47.39)			
iv2			0.942***	
			(140.59)	
ESG		-0.169**		-0.138***
		(-2.13)		(-3.75)
Controls	YES	YES	YES	YES
Company	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	20,335	20,335	20,335	20,335

Note: *** p < 0.01, ** p < 0.05, * p < 0.1, and the t-values are in parentheses.

(2) Instrumental variable method: The average ESG score of enterprises in the same city during the same year may reflect the overall environmental, social, and governance conditions of that city. This implies that this average can capture the city-specific policies, culture, and economic environment, which may be related to the ESG performance of individual enterprises but unrelated to the carbon intensity of other enterprises. Enterprises in the same industry within the same city face similar market conditions, policy environments, and social expectations. Therefore, the average ESG score of the same industry may influence an enterprise's ESG performance. Enterprises in the same industry are usually affected by similar regulations and industry standards, making this average related to an enterprise's ESG performance but unrelated to the carbon intensity of other enterprises. Consequently, the average ESG score of enterprises in the same city during the same year (iv1) and the average ESG score of enterprises

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in the same industry and city during the same year (iv2) are selected as instrumental variables for the 2SLS regression. From the first-stage results in Columns (1) and (3) of Table 3, it can be seen that both instrumental variables are significant at the 1% confidence level, meeting the relevance assumption. Columns (2) and (4) in Table 3 indicate that the results remain robust, and both instrumental variables pass the weak instrumental variable test.

4.2.2. Other Robustness Tests

The results of other robustness tests are shown in Table 4. The regression is carried out by replacing the scores assigned to the ESG rating and its sub-items with their comprehensive scores. As can be seen from Table 4, after replacing the core explanatory variables, ESG investment and its three sub-items still have a significant negative impact on the carbon intensity of enterprises, and the regression results are robust.

Table 4. Results of Other Robustness Tests

	(1)	(2)	(3)	(4)
	L.intensity	L.intensity	L.intensity	L.intensity
Comprehensive Score of ESG	-0.033***			
	(0.006)			
Comprehensive Score of E		-0.015***		
		(0.005)		
Comprehensive Score of S			-0.012***	
			(0.003)	
Comprehensive Score of G				-0.018***
				(0.004)
Constant	-14.675***	-15.994***	-15.872***	-15.133***
	(1.851)	(1.832)	(1.834)	(1.849)
Controls	YES	YES	YES	YES
Company	YES	YES	YES	YES
Year	YES	YES	YES	YES

4.3. Heterogeneity Analysis

When analyzing the impact of ESG investment on the carbon intensity of enterprises, it is of great importance to consider the heterogeneity between labor-intensive and non-labor-intensive enterprises. Labor-intensive enterprises mainly refer to those whose production processes rely predominantly on manual labor and usually have high labor costs. Examples include manufacturing, agriculture, catering, and certain service industries. Non-labor-intensive enterprises mainly refer to those that adopt a higher proportion of mechanization or automation in their production processes, such as high-tech manufacturing, information technology services, and the financial services industry. As can be seen from Table 5, ESG investment has a significant negative impact on the carbon intensity of non-labor-intensive enterprises, while its negative impact on the carbon intensity of labor-intensive enterprises is not significant. Non-labor-intensive enterprises usually have a larger capital base, enabling them to invest in low-carbon technologies and innovations, thus effectively reducing carbon intensity. Moreover, a high level of ESG performance helps non-labor-intensive enterprises enhance their brand image, gain a competitive edge in the market, and further promote investment. Labor-intensive enterprises, with their inherently low-profit margins, may find it difficult to bear the additional costs of ESG investment.

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Table 5. Results of the Heterogeneity Analysis

	(1)	(2)
	non-labor-intensive	labor-intensive
ESG	-0.170***	-0.093
	(0.030)	(0.058)
Constant	-17.942***	-9.644**
	(1.979)	(4.454)
Controls	YES	YES
Company	YES	YES
Year	YES	YES
Observations	15,727	4,608
R-squared	0.190	0.194

4.4. Mechanism Analysis

Based on the theoretical analysis, the mechanisms through which ESG investment reduces the carbon intensity of enterprises are examined from two channels: improving the asset turnover rate and reducing the operating expense ratio. In Column (1) of Table 6, the coefficient of ESG investment is significantly positive at the 10% confidence level, indicating that ESG investment can improve the asset turnover rate. The coefficient of the asset turnover rate in Column (2) is significantly negative, suggesting that ESG investment can reduce the carbon intensity of enterprises by optimizing resource allocation and increasing asset turnover, thus verifying Hypothesis H2.

Similarly, in Column (3) of Table 6, ESG investment can significantly reduce the operating expense ratio of enterprises at the 1% confidence level. The coefficient of the operating expense ratio in Column (4) is significantly positive, meaning that the higher the operating expense ratio, the higher the carbon intensity of the enterprise. That is, ESG investment can reduce the carbon intensity of enterprises by promoting enterprises to reduce operational consumption and lower environmental compliance costs, and Hypothesis H3 is verified.

Table 6. Results of the mechanism analysis.

	(1)	(2)	(3)	(4)
	ATO	intensity	Ofee	intensity
ESG	0.003*		-0.003***	
	(0.002)		(0.001)	
ATO		-0.514***		
		(0.119)		
Ofee				1.536***
				(0.384)
Constant	1.449***	14.926***	0.699***	13.177***
	(0.097)	(1.626)	(0.030)	(1.648)
Controls	YES	YES	YES	YES
Company	YES	YES	YES	YES
Year	YES	YES	YES	YES
R-squared	0.823	0.199	0.848	0.199

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5. Conclusion and Suggestions

5.1. Conclusion

Against the economic backdrop of the "dual carbon" goals and "high-quality development," the environmental, social, and governance (ESG) performance of enterprises has gradually received widespread attention. This paper selects Chinese listed companies in the Shanghai and Shenzhen A-share markets from 2011 to 2022 as the research sample to empirically examine the impact of ESG investment on the carbon intensity of enterprises and the underlying mechanisms. The research findings are as follows. First, ESG investment and its three sub-items can significantly reduce the carbon intensity of enterprises, and this conclusion remains robust even after considering the issue of endogeneity. This implies that ESG investment is not only a manifestation of enterprises fulfilling their social responsibilities but also an important means for enterprises to improve their environmental performance. In particular, after controlling for a series of factors that may affect the carbon intensity of enterprises, the negative impact of ESG investment remains significant. Second, the heterogeneity analysis reveals that ESG investment can significantly reduce the carbon intensity of non-labor-intensive enterprises. Non-labor-intensive enterprises usually possess stronger capital strength and technical capabilities, enabling them to more effectively transform ESG practices into improvements in environmental efficiency, thus achieving a lower carbon intensity. In contrast, labor-intensive enterprises may face more challenges during the transformation process, such as financial constraints and insufficient technological innovation, resulting in a relatively weak response to ESG investment. Third, the mechanism analysis shows that ESG investment reduces the carbon intensity of enterprises through two channels: improving the asset turnover rate and reducing the operating expense ratio. ESG investment drives enterprises to optimize resource allocation and management processes, thereby enhancing the efficiency of asset utilization. By improving environmental management practices and increasing production efficiency, enterprises can consume fewer resources per unit of output, thus reducing carbon emissions. This optimization not only helps enterprises make better use of existing resources but also promotes their investment in technological innovation and the development of green products. ESG investment helps enterprises implement energy conservation and emission reduction measures and green management, which not only enhances the social image of enterprises but also reduces operating costs in the long run. For example, by introducing renewable energy sources and optimizing logistics and supply chain management, enterprises can reduce energy expenditures and waste treatment costs, all of which directly lead to a reduction in the enterprise's carbon footprint.

5.2. Policy Suggestions

First, strengthen government supervision and guidance and enhance the ESG investment incentive mechanism. The government should continue to introduce and improve relevant policies to encourage enterprises to make green investments and technological innovations, especially support policies for non-labor-intensive enterprises. Establish a sound incentive and punishment mechanism to ensure that enterprises fulfill their environmental protection responsibilities. In terms of financial subsidies and tax incentives, the government can provide financial subsidies or tax exemptions for enterprises that make ESG investments to encourage more enterprises to actively participate in sustainable development. In particular, for labor-intensive enterprises, the burden of their transformation can be alleviated through subsidy funds. Establish a special green credit mechanism to encourage financial institutions to provide low-interest loans to enterprises with clear ESG investment plans, thereby reducing financing costs and promoting the green transformation of enterprises.

Second, improve the internal management level of enterprises. Enterprises should attach importance to the role of ESG investment in resource management and technological innovation. By optimizing resource allocation and production processes, they can increase the asset turnover rate and reduce the operating expense ratio. Strengthen environmental protection training for employees, enhance the energy conservation awareness of all employees, and reduce the waste of energy and resources. Guide enterprises to integrate sustainable development goals into their business strategies, especially in terms of carbon emission management. By setting specific emission reduction targets and timetables, enterprises are urged to implement the concept of sustainable development in their operations.

Third, strengthen supervision and information disclosure. Improve ESG reporting standards, formulate unified ESG reporting standards and disclosure frameworks, increase the transparency of enterprises' ESG performance, and enhance the basis for investors' decision-making. Through transparent information disclosure, investors can understand the ESG investment performance and carbon emission situations of enterprises, thus prompting enterprises to make more active ESG investments. Strengthen the supervision mechanism, establish corresponding supervision mechanisms to ensure that enterprises follow relevant standards and commitments when making ESG investments, severely punish behaviors of failing to fulfill ESG investment obligations, and enhance the awareness of compliance.

Fourth, implement differentiated policies for different regions and industries. Design targeted policies. Considering the differences among regions and industries, formulate differentiated policies to adapt to the actual situations of different enterprises. For example, implement more incentive measures in carbon-intensive industries and economically backward regions to help these enterprises achieve low-carbon transformation. Focus on supporting labor-intensive enterprises. According to the characteristics of labor-intensive enterprises, formulate targeted regulations and support policies, and encourage their investment in technological upgrading and efficient resource utilization to achieve a greater reduction in carbon intensity.

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