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A Study on the Impact of Corporate ESG Performance on Green Innovation Performance in a Dual-Carbon Context

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Abstract: *In the process of promoting the reform of the "dual-carbon" target, realizing the mutual promotion and synergistic development of corporate ESG performance, government subsidies, and green innovation performance is not only an inevitable strategic choice for enterprises to obtain higher quality development but also the key to ensuring economic and social benefits. The relationship model between corporate ESG performance, government subsidies, and green innovation performance is constructed and empirically tested using A-share listed companies in Shanghai and Shenzhen from 2012 to 2021 as the research object. Countermeasures are proposed to strengthen corporate ESG performance and further improve corporate green innovation performance.*

Keywords: *Corporate ESG performance; Government subsidies; Green innovation performance*

1. Introduction

Enterprise ESG performance refers to the three English word acronym of environmental, social, and governance performance, which breaks through the once single aspect of corporate financial performance concerns and chooses to summarize the enterprise's environmental, social, and governance performance together into a comprehensive evaluation system for assessment. There are three main categories of corporate ESG performance behaviors, one is that ESG performance behaviors affect corporate performance. The research of Li Jinglin et al [1]shows that the relationship between ESG performance and the three dimensions of environment, society, and governance has a significant contribution to corporate performance. Second, ESG performance promotes government subsidies. Wang Wei [2] used Hexun.com ESG performance score data to conduct a study and found that the higher the environmental score of a company, the more it will help the government to accomplish more environmental governance tasks and the more government subsidies it will receive. Third, ESG performance behaviors will promote corporate green innovation. Zhang et al [3] conducted a study based on data from China's Shanghai and Shenzhen stock markets and found that environmental, social, and governance measures will promote corporate green innovation.

Compared with the traditional financial performance, green innovation performance focuses more on "ecological" issues and puts forward new requirements on the environmental management of its production process. From the perspective of impact effect, some scholars have proposed that when evaluating green innovation performance, the enterprise's human resources, equipment, capital flow, and other factors should also be included, to reflect that green innovation performance has a positive effect on reducing the cost of production factors within the enterprise and improving the efficiency of resource utilization[4].

The current research on government subsidies is divided into two types: one is the research on the effectiveness of government subsidies themselves, that is, whether government environmental subsidies will increase the enterprise's green technological innovation investment to enhance the green innovation capacity. Lu Hongyou, Deng Tanqin, and Yu Jinliang [5] found that after receiving the subsidy, the environmental investment is significantly increased due to the influence of policy-oriented and government-regulated enterprises. Secondly, they study whether environmental subsidies can achieve economic development. Liu Haiying and Ding Ying [6] found that the government's environmental subsidies will lead to a decline in per capita output, so the government's environmental subsidies can not achieve economic growth and a "win-win" for pollution emissions.

In the context of high-quality economic development, how to realize sustainable development from

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the enterprise level and innovation-based sustainable development has become the focus of attention of the current academic community. Based on stakeholder theory, sustainable development theory, and principal-agent theory, this paper investigates whether enterprises can realize their green innovation performance and enhance their sustainable development capability while taking into account their environmental and ecological responsibilities. Exploring the impact of corporate ESG performance on green innovation performance using the mediation effect model helps to enrich existing research.

2. Theoretical Analysis and Research Hypotheses

2.1. Corporate ESG performance and Green innovation performance

ESG performance evaluates the social benefits generated by enterprises from the aspects of environmental protection, social responsibility, and corporate governance, while the green innovation performance of enterprises refers to the ecological benefits pursued by enterprises. Based on the stakeholder theory [7], enterprises should pursue the maximization of overall interests, and the improvement of enterprise performance requires the joint participation of all stakeholders. The sustainable development theory[8] holds that corporate performance mainly depends on the health level of the company's long-term operation. Good ESG performance means that enterprises pay more attention to operational compliance and sustainable development, and comprehensively reduce all kinds of potential ESG risks, to realize a win-win situation in various aspects such as economy, society, and ecology, which in turn improves investors' confidence in the development of the enterprise and realizes the benign cycle of capital. Therefore, this paper proposes the hypothesis:

H1: Good corporate ESG performance significantly enhances Green innovation performance.

2.2. Corporate ESG performance and Government subsidies

Government subsidies refer to the government's non-reimbursable financial funds to enterprises. In terms of enterprise environmental protection performance, the better the ESG performance, the stronger the enterprise's awareness of environmental protection, and the government will continue to encourage the relevant enterprises to continue to promote enterprise environmental protection. From the perspective of CSR performance, good ESG performance will increase intangible assets and establish a positive social image. Based on the social exchange theory, the government will have a favorable impression of companies with a high sense of social responsibility and will give preference to such companies when subsidizing them. In terms of corporate governance performance, good ESG performance indicates that this type of company has a strong level of governance, and it is easier to gain the trust and support of the government in consideration of government subsidies and obtain government subsidies. Therefore, this paper proposes the hypothesis:

H2: Good ESG performance of enterprises significantly enhances Government subsidies.

2.3. Government subsidies and Green innovation performance

The characteristics of green innovation, such as high investment, long-term, and high risk, affect the enthusiasm of enterprises to implement green innovation to a certain extent, while government subsidies can spread the risk of innovation and provide incentives for enterprises to implement green innovation. Government subsidies can also send positive signals to enterprises so that they can further absorb funds for enterprise development and promote the improvement of green innovation. Overall, government subsidies can help other stakeholders to enhance their trust and support for enterprises, and can also attract social capital investment through its spillover effect, creating a favorable internal and external environment for enterprises' green innovation. Therefore, this paper proposes the hypothesis:

H3: Government subsidies can enhance Green innovation performance.

2.4. Corporate ESG performance, Government subsidies, and Green innovation performance

To achieve the goal of environmental governance, the government adopts the way of issuing environmental subsidies to strengthen the awareness of corporate environmental responsibility and guide them to actively participate in environmental protection construction and realize green R&D and innovation. The good social performance of enterprises is the process of optimizing resource allocation and realizing value re-creation through government subsidies, and it is also the feedback on the reality

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

of government subsidies. According to stakeholder theory [7], government subsidies can not only maintain a good relationship with the government, but also enhance the relationship between the enterprise and other stakeholders, reduce the risk of information asymmetry and principal-agent costs, and at the same time, it also accumulates a variety of tangible and intangible assets for the enterprise's green innovation. Enterprise green innovation is a strategy adopted by enterprises to realize the goal of sustainable development, and its successful promotion and realization depend on good corporate governance. Good corporate governance is to enhance the quality of management under the guidance of sustainable development, through government subsidies and other means, to promote the improvement of the efficiency of enterprise resource utilization and the formulation and implementation of green innovation strategies supporting the government's development plan. Therefore, this paper proposes the hypothesis:

H4: There is a mediating effect of Government subsidies between Corporate ESG performance and Green innovation performance.

3. Research Design

3.1. Sample Selection and Data Source

This paper selects A-share listed enterprises in Shanghai and Shenzhen from 2012 to 2021 as the research sample and screens the relevant data as follows: excluding financial and insurance enterprises, ST and *ST enterprises, and enterprises with missing variable measurements, and finally obtaining 18,493 observations. The data on the ESG performance of enterprises come from the CSI ESG score database, the data related to green innovation patents come from the China Research Data Service Platform (CNRDS), and the data on the rest of the variables come from the Wind database.

3.2. Variables Description

3.2.1. Explained Variables

Green Innovation Performance (GI). Based on the mature research methods of many scholars such as Bo Qun[9], the total number of green patent applications of enterprises in the current year is adopted as a measure of green innovation performance. This paper applies the total number of green patent applications of enterprises in the current year plus one and takes its natural logarithm to measure green innovation performance.

3.2.2. Explanatory Variables

ESG performance (ESG). This paper draws on Xiao Gao Jieying and Song Qikun et al[10][11]study to select the China Securities ESG rating agency for listed companies ESG rating as the data of this paper's ESG performance score. The CSI ESG rating is divided into nine grades, from low to high as C, CC, CCC, B, BB, BBB, A, AA, and AAA, assigning the rating C~AAA in order of 1~9.

3.2.3. Mediating Variables

Government subsidy (Sub). Drawing on the study of Ye Cuihong and Wang Xi et al [12], the total amount of government subsidies received by the enterprise in the year is taken as the natural logarithm as a measure of government subsidies. To avoid significant disparities in the numerical values of government subsidies compared to other related data, choose the logarithmic transformation.

3.2.4. Control Variables

Based on existing research, this paper draws on the research of Li Jinglin [13], Yang Jinkun [14]and Luo Yuanda [15], etc., and introduces relevant control variables including return on total assets (Roa), gearing ratio (Lev), enterprise size (Size), proportion of shares held by the first largest shareholder (Top1), the combination of two jobs (Dual), the independence of the board of directors (Indep), and the value of the enterprise (TobinQ). value (TobinQ). The definition and measurement of the variables are shown in Table 1.

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

Table 1 Variable definitions

Variable name	Variable symbol	Variable definition
Corporate ESG performance	ESG	Total corporate social, environmental, and governance score
Green Innovation Performance	GI	(1+total number of green patent applications) taking natural logarithms
Government subsidies	Sub	Total government subsidies in natural logarithms
Return on Total Assets	Roa	Net Profit After Tax/Total Assets
Leverage ratio	Lev	Liabilities/Total Assets
Dual	Dual	Take 1 if the chairman and general manager are the same person, otherwise take 0
Top1 Shareholding Ratio	Top1	Proportion of shareholding of the largest shareholder to the total share capital
Board independence	Indep	Ratio of number of independent directors to board of directors
Tobin's Q	TobinQ	Firm market value/replacement cost

3.3. Model design

According to the previous assumptions, this paper constructs the theoretical model in Figure 1 as follows:

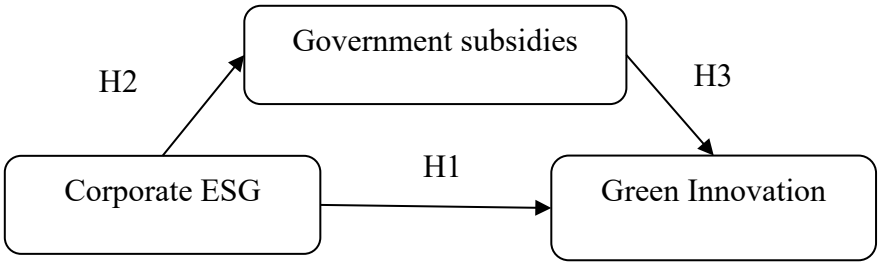

Fig. 1 Theoretical model

In order to examine the mediating effect of government subsidies on the impact mechanism of corporate ESG performance on green innovation performance, this paper draws on the research of Wen Zhonglin et al[16]and applies the stepwise regression method to test the relationship between the three. The model is constructed as follows:

$$GI_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha_2 control_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$Sub_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 control_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$GI_{i,t} = \gamma_0 + \gamma_1 Sub_{i,t} + \gamma_2 control_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$GI_{i,t} = \delta_0 + \delta_1 ESG_{i,t} + \delta_2 Sub_{i,t} + \delta_3 control_{i,t} + \varepsilon_{i,t} \quad (4)$$

Where, model (1) verifies the influence of enterprise ESG performance on green innovation performance (GI), model (2) verifies the influence of enterprise ESG performance on the mediating variable (Sub), and model (3) verifies the influence of the mediating variable (Sub) on green innovation performance (GI).Model (4) further verifies whether corporate ESG performance has an effort on green innovation performance when controlling the mediating variables.According to the regression idea of mediation effect test, if the coefficient α1 is significant, model (2) is used to test the influence of enterprise ESG performance on the mediating variable; if the coefficient β1 is significant, model (4) is used to analyze: if the coefficient δ1 of model (4) is significantly not 0 and the absolute value of the coefficient of δ1 in model (4) is less than the absolute value of the coefficient of α1 in model (1), it indicates that the enterprise ESG now affects the level of green innovation performance through the mediating variable (Sub).

4. Empirical Research and Results Analysis

4.1. Descriptive statistical analysis

This paper utilizes STATA 17.0 software to analyze the descriptive statistics of each variable, and the results are shown in Table 2 below:

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

Table 2 Descriptive statistical analysis of variables

Variable name	Sample size	Mean value	Standard deviation	Minimum value	Median	Maximum value
ESG	18493	6.5877	1.114	1.00	6.00	9.00
GI	18493	0.6058	0.973	0.00	0.00	4.19
Sub	14339	15.7577	2.125	5.22	15.96	23.11
Roa	18493	0.0393	0.056	-0.22	0.04	0.19
Lev	18493	0.4277	0.201	0.06	0.42	0.87
Top1	18493	34.7132	14.856	8.80	32.77	74.82
Dual	18493	0.2755	0.447	0.00	0.00	1.00
Indep	18493	0.3794	0.065	0.25	0.36	0.60
TobinQ	18493	2.0924	1.932	0.64	1.62	92.30

Descriptive statistical analysis of the sample as a whole through the above table reveals that among the A-share listed companies in Shanghai and Shenzhen, the mean value of enterprise ESG performance (ESG) is 6.5877, the standard deviation is 1.114, the maximum value is 9.00, and the minimum value is 1.00, which indicates that there is a big difference in the ESG performance of different types of enterprises with a high degree of relativity. The mean value of green innovation performance (GI) is 0.6058, the standard deviation is 0.973, the maximum value is 4.19, and the minimum value is 0.00, which indicates that some enterprises pay high attention to green innovation but pay less attention to green innovation, resulting in low green innovation performance. The mean value of government subsidy (Sub) is 15.7577, the standard deviation is 2.1225, the maximum value is 23.11, and the minimum value is 5.22, which indicates that different types of enterprises are subject to a large difference in government subsidies.

4.2. Correlation analysis

This paper utilizes STATA 17.0 software to analyze the correlation of each variable, and the specific results are shown in Table 3 below. From the data in the table, it can be seen that the correlation coefficients of ESG performance of enterprises (ESG) and green innovation performance (GI), ESG performance of enterprises and government subsidies (Sub), and government subsidies (Sub) and green innovation performance (GI) are 0.087, 0.178 and 0.125, and all of them are significant at the 1% level, and all of them are significantly positively correlated. Therefore, the regression analysis can be continued.

Table 3 Results of correlation analysis of variables

variable	ESG	GI	Sub	Roa	Lev	Top1	Dual	Indep	TobinQ
ESG	1								
GI	0.087***	1							
Sub	0.178***	0.125***	1						
Roa	0.117***	0.038***	0.042***	1					
Lev	0.119***	0.112***	0.163***	-0.366***	1				
Top1	0.114***	-0.00600	0.107***	0.105***	0.081***	1			
Dual	-0.111***	0.00300	-0.087***	0.028***	-0.136***	-0.051***	1		
Indep	-0.017**	0.00500	0.015*	0.020***	-0.039***	0.024***	0.116***	1	
TobinQ	-0.074***	-0.059***	-0.066***	0.109***	-0.225***	-0.096***	0.065***	0.052***	1

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3. Regression analysis

This paper uses STATA 17.0 to conduct regression analysis on 18,493 samples of Shanghai and Shenzhen A-share companies, and the results of regression analysis and the regression coefficients between each relevant variable are shown in the following table.

According to the data of model (1) in Table 4, the regression coefficient of corporate ESG performance is significant at 1% level, which is 0.0570, indicating that the better the corporate ESG performance is, the better the corporate green innovation performance is among the listed companies in Shanghai and Shenzhen A-shares, and H1 is verified. In model (2), the regression coefficient of corporate ESG performance is 0.256, which is significant at the 1% level, indicating that corporate ESG performance has a significant positive impact on government subsidies, and H2 is verified. In model (3), there is a significant positive relationship between government subsidies and green innovation performance, and the regression coefficient of government subsidies is 0.0480 and significant at a 1% level. In model (4), the regression coefficient of ESG performance of Shanghai and Shenzhen A-share listed companies is 0.0490, which is significant at a 1% level; the regression coefficient of government

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

subsidies is 0.0447, which is significant at a 1% level, indicating that the government subsidies play a partially intermediary role between the green innovation performance and the ESG performance of enterprises, and H4 is verified.

Table 4 Results of the baseline regression analysis

Variable	(1)M1 GI	(2)M2 Sub	(3)M3 GI	(4)M4 GI
ESG	0.0570***	0.256***		0.0490***
	(8.71)	(15.96)		(6.65)
Roa	1.517***	3.541***	1.341***	1.182***
	(10.84)	(9.91)	(8.28)	(7.23)
Lev	0.650***	1.710***	0.489***	0.452***
	(16.50)	(17.79)	(11.09)	(10.20)
Top1	-0.00237***	0.00907***	-0.00212***	-0.00236***
	(-4.88)	(7.71)	(-3.95)	(-4.39)
Dual	0.0568***	-0.253***	0.0394**	0.0492***
	(3.52)	(-6.40)	(2.19)	(2.73)
Indep	0.140	0.772***	0.100	0.0973
	(1.29)	(2.92)	(0.83)	(0.81)
TobinQ	-0.0197***	-0.0183*	-0.0246***	-0.0230***
	(-5.23)	(-1.67)	(-4.90)	(-4.58)
Sub			0.0480***	0.0447***
			(12.70)	(11.72)
_cons	-0.0524	12.69***	-0.386***	-0.632***
	(-0.83)	(82.76)	(-5.03)	(-7.43)
N	18493	14339	14339	14339
F	72.63	146.5	60.72	58.82
R^2	0.0268	0.0668	0.0288	0.0318

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.4. Robustness test

Table 5 Test results of replacing explanatory variables

variable	(1) GI	(2) GI
ESG	0.0490***	
	(6.65)	
ESG Bloomberg		0.0376***
		(23.59)
Roa	1.182***	1.177***
	(7.23)	(4.14)
Lev	0.452***	0.315***
	(10.20)	(3.82)
Top1	-0.00236***	-0.00336***
	(-4.39)	(-4.00)
Dual	0.0492***	0.109***
	(2.73)	(3.24)
Indep	0.0973	-0.0668
	(0.81)	(-0.33)
TobinQ	-0.0230***	-0.0277***
	(-4.58)	(-2.69)
Sub	0.0447***	0.0697***
	(11.72)	(11.19)
_cons	-0.632***	-1.450***
	(-7.43)	(-10.60)
N	14339	6150
F	58.82	99.35
R^2	0.0318	0.115

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Some literature studies have indicated that some scholars [17][18][19] use the more authoritative ESG scores published by Bloomberg to measure corporate ESG performance. Therefore, to make the empirical results more reliable, this study will use the ESG score data published by Bloomberg to replace the CSI ESG score to measure corporate ESG performance. The regression results calculated after replacing the variables are shown in Table 5. The results show that after replacing the ESG score indicator

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

(i.e., ESGBloomberg), the regression coefficient between corporate ESG performance and green innovation performance reaches 0.0376 and is significantly positive at the 0.1% level, which suggests that corporate ESG performance enhances green innovation performance and Hypothesis H1 still holds. After replacing the explanatory variables, the mediating effect of government subsidies is further examined, and the coefficient of the interaction term between corporate ESG performance and green innovation performance reaches 0.0376 and is significant at the 1% level, which implies that government subsidies positively mediate between corporate ESG performance and green innovation performance, and Hypothesis H4 still holds.

5. Conclusion

5.1. Research findings

At present, China is moving towards the direction of high-quality economic development, and with the continuous growth of the gross national product, financial revenue, corporate profits and per capita income, problems in corporate environmental protection, social responsibility and corporate governance are gradually appearing. How to promote the sustainable development of economic, social and environmental health in general is an important task for the people's governments at all levels in China, and it is also a topic of great concern for stakeholders. Good ESG performance is crucial for enterprises to obtain capital, gain competitive advantage and realize sustainable development. Based on the stakeholder theory, sustainable development theory and principal-agent theory, this paper takes the A-share listed companies in Shanghai and Shenzhen from 2012 to 2021 as samples, and empirically examines the impact of corporate ESG performance on green innovation performance and whether there is an intermediary effect of government subsidies therein by using empirical tests. The main research conclusions are:

First, corporate ESG performance is significantly and positively related to green innovation performance, indicating that the better the corporate ESG performance, the higher its green innovation performance will be. Under the environment of sustainable development advocated by the international community, enterprises should actively improve their production technology and shape a good image of their own long-term development, so as to lay the foundation for the long-term sustainable growth of their green innovation performance.

Secondly, government subsidies are significantly positively correlated with green innovation performance, and there is an obvious positive relationship between the two. The more government subsidies, the better the green innovation behavior of enterprises and the higher the green innovation performance achieved. Government subsidies are mainly used as the main means to subsidize enterprises to carry out green innovation to make up for the technical and economic deficiencies caused by technical and financial factors. After receiving government subsidies, enterprises can use them to invest in R&D and improve production capacity, which in turn improves their green innovation level and green innovation performance.

Third, government subsidies have an obvious positive impact on the ESG performance and green innovation performance of enterprises. On the one hand, enterprises can make use of government subsidies to improve their green innovation performance, so as to realize the development of the whole social and economic system in a sustainable direction. On the other hand, enterprises with higher ESG performance tend to have higher green innovation ability and level, and can realize sustainable development in the fierce market competition. It can be seen that government subsidies mediate and positively promote the relationship between ESG performance and green innovation performance.

5.2. Policy Implications

First, improve the ESG practice process and enhance enterprises' ESG performance.ESG performance can show the awareness of enterprises to take the initiative to assume responsibility and future sustainable development ability, so enterprises need to change their awareness in the development process and take the initiative to improve their performance in environmental protection, social responsibility, and corporate governance, and then the ESG performance score will be improved, which will help to enhance the green innovation level of enterprises. Second, improve the ESG disclosure system.

Second, improve the ESG disclosure system and strengthen the responsibilities of regulatory agencies.

ISSN 2616-5902 Vol. 5, Issue 26: 52-60, DOI: 10.25236/AJBM.2023.052609

At present, China's ESG disclosure system is still in its infancy, and the relevant systems and policies still need to be perfect. The government should actively promote the improvement of the ESG disclosure system to reduce or even avoid the disclosure of false environmental, social responsibility, and corporate governance information by enterprises, and promote the long-term healthy and stable development of enterprises and the capital market. The government should give praise and policy rewards to enterprises that actively undertake social responsibility and proactively disclose ESG information, and impose appropriate penalties on enterprises with weak awareness of social responsibility, failing to disclose social responsibility information promptly or with substandard information, to make enterprises more proactive and standardized in ESG disclosure.

Third, build a multi-party ESG mechanism to help the public promote development. Public attention can alleviate the financing constraints of enterprises, reduce the short-sighted behavior of executives, and thus improve the innovative performance of enterprises, which is of great significance to the stakeholders of enterprises represented by individual investors. In addition, talent is the main body of innovation and plays a crucial role. It is necessary to take human capital as the core to enhance enterprises' absorptive capacity enterprises for green innovation and to give full play to the positive spillover effects of green innovation.

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