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The Relationship Between Corporate ESG Performance and Innovation Input Intensity In China: An Analysis Based on the Industrial Heterogeneity of High-Tech Enterprises

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Abstract:Based on the stakeholder theory and competitive strategy theory, this paper takes the financial data of Chinese A-share listed companies on the Shanghai Stock Exchange of China from 2008 to 2024 as the research sample, and empirically examines the relationship between corporate ESG performance and innovation input intensity(IPI) by adopting the multiple linear regression method. The results show that good ESG performance can significantly promote the improvement of corporate innovation input intensity. From the perspective of industrial heterogeneity, the positive impact of ESG performance on innovation input intensity is more prominent in high-tech enterprises. This study optimizes the measurement index of innovation input and explores the industry heterogeneity of the impact of ESG performance, which enriches the research on the economic consequences of corporate ESG performance and provides practical references for enterprises to improve ESG performance and increase innovation investment.

Keywords: ESG Performance; Innovation Input Intensity; High-Tech Enterprises; Competitive Strategy; Industrial Heterogeneity

1. Introduction

In recent years, global ESG has stepped into the stage of mandatory compliance and value creation, and innovation investment has become the core support for the implementation of ESG goals. For China, the dual carbon goals and the cultivation of new productive forces have driven the in-depth integration of ESG and R&D. With the support of relevant policies, both have become key drivers for the high-quality development of enterprises.

From the perspective of existing research, listed companies around the world are paying increasing attention to fulfilling social responsibilities and striving to achieve good ESG performance.[1][2] Besides, good ESG performance is conducive to enhancing enterprises' core competitiveness in the market[3], and it can motivate enterprises to continuously improve scientific[4] and technological innovation achievements, such as increasing the number of patents and intangible assets. [5]However, there are obvious limitations in existing studies: the heterogeneous impact of enterprise scale is not considered, and the innovation input index is not optimized to a more comparable innovation input intensity, leading to certain biases in research conclusions. In addition, existing studies have not fully considered the industrial heterogeneity of high-tech enterprises. Therefore, this paper will put forward relevant research hypotheses in the second part.

The innovations of this paper are as follows: First, the innovation input index is optimized to innovation input intensity (R&D expenses / operating revenue), and the t+1 period is adopted to examine the forward-looking impact of ESG, avoiding index biases caused by differences in enterprise scale. Second, from the perspective of industrial heterogeneity, it tests the moderating effect of ESG on innovation input in high-tech enterprises, making up for the deficiency of insufficient attention to industrial characteristics in existing studies. Third, the enterprise life cycle is incorporated into the analysis framework, and enterprise age is controlled in the model, so as to examine the heterogeneous factors affecting innovation in a more comprehensive way.

This paper will be developed in the following structure: the first part is the introduction.The second part is theoretical analysis and research hypotheses. The third part is model introduction.The fourth part is empirical analysis

based on the model, including multiple linear regression model and robustness test.The fifth part presents the two main conclusions of this paper and the prospects for enterprise operation and development.

2. Theoretical Analysis and Research Hypotheses

From the perspective of stakeholder theory, good ESG performance is beneficial to enterprises' scientific and technological innovation from four aspects: employees, consumers, investors and the government.[6] First, good ESG performance helps to build a good corporate image, reflects the enterprise's strong operational capabilities, and is conducive to attracting scientific and technological talents and improving the efficiency of corporate innovation. [7]Second, for consumers, a good corporate image can promote consumers to purchase the enterprise's products, thereby improving the enterprise's profitability and enabling more funds to be invested in innovation. Third, it can attract investors' capital and reduce financing costs, which is conducive to alleviating the financial pressure on enterprises caused by enhancing innovation input intensity. Finally, enterprises' fulfillment of social responsibilities can make the government increase support for them, and increasing innovation input intensity is an important aspect of government support.

Based on the above analysis, this paper puts forward Hypothesis H1: The better the corporate ESG performance, the higher the corporate innovation input intensity.

From the perspective of Michael Porter's competitive strategy theory, high-tech enterprises adopt differentiation strategy or focus strategy[8]. Since the improvement of core competitiveness of high-tech enterprises relies more on the enhancement of their own scientific and technological strength, high-tech enterprises tend to have a stronger willingness to innovate. Moreover, scientific and technological innovation is a project with high risks and high returns, so high-tech enterprises are more willing to reduce financing costs through good ESG performance.[9] Therefore, the significance of the impact of ESG performance on innovation input in high-tech enterprises is significantly greater than that in non-high-tech enterprises.

Based on the above analysis, this paper puts forward Hypothesis H2: The impact of ESG performance on innovation input in high-tech enterprises is greater than that in non-high-tech enterprises.

3. Model Introduction

3.1 Sample Source

This paper takes the A-share listed companies on the Shanghai Stock Exchange of China from 2008 to 2024 as the initial sample to analyze the impact of corporate ESG performance on their innovation input. On the basis of the initial data, the samples of financial enterprises, ST enterprises and those with missing data are excluded.

First, the business model of financial enterprises has a weak correlation with innovation input, so they are excluded.[10] Second, ST enterprises are often in poor operating conditions and lack the ability to fulfill social responsibilities, and their innovation input is often insufficient. More importantly, the credibility of financial and non-financial data of such enterprises is relatively low, so they cannot be included in the research scope. Finally, in order to avoid the impact of extreme values due to the extremely high R&D investment of some start-ups, this paper winsorizes the top 1% of samples in terms of innovation input intensity. The ESG performance data are obtained from Chinese famous Huazheng ESG Ratings, and the remaining data are from the CSMAR Database.

3.2 Variable Definition

The specific definitions of each variable in this paper are shown in Table 1:

Table 1. Definition of Variables

Variable Category	Variable Name	Variable Symbol	Calculation Explanation
Dependent Variable	Innovation Input Intensity	IPI	(Annual R&D expenses / Operating revenue) × 100
Independent Variable	ESG Performance	ESG	The logarithmic value of Huazheng Index ESG score ranging from 1 to 9
Moderating Variable	High-Tech Enterprise	HTE	Assigned 1 if it is a high-tech enterprise, 0 otherwise
Control Variable	Firm Age	AGE	Logarithmic value of (Current year - Founding year + 1)
Control Variable	Asset-Liability Ratio	ADR	Ratio of total liabilities at the end of the year to total assets at the end of the year

Control Variable	Return on Assets	ROA	Ratio of net profit to total assets
Control Variable	Year	YEAR	Year fixed effects

Note: The t+1 period of innovation input intensity is adopted to examine the forward-looking impact of ESG. The classification of high-tech enterprises is based on the provisions of the Shanghai Stock Exchange.

3.3 Model Construction

This paper adopts the method of multiple linear regression analysis.

First, this paper constructs Model 1 to verify Hypothesis H1, as follows:

$$IPI_{i,t+1}=\alpha_1+\alpha_2 ESG_{i,t}+\alpha_3 AGE_{i,t}+\alpha_4 ADR_{i,t}+\alpha_5 LOSS_{i,t}+\alpha_6 ROA_{i,t}+\sum YEAR+\varepsilon \quad (1)$$

In Model 1, the dependent variable is Innovation Input Intensity (IPI) and the independent variable is ESG Performance (ESG). If the coefficient of ESG Performance (ESG) is significantly positive with other variables controlled, it can be indicated that Hypothesis H1 is valid.

Second, this paper constructs Model 2 to verify Hypothesis H2, as follows:

$$IPI_{i,t+1}=\alpha_1+\alpha_2 ESG_{i,t}\times HTE_{i,t}+\alpha_3 HTE_{i,t}+\alpha_4 AGE_{i,t}+\alpha_5 ESG_{i,t}+\alpha_6 ADR_{i,t}+\alpha_7 LOSS_{i,t}+\alpha_8 ROA_{i,t}+\sum YEAR+\varepsilon \quad (2)$$

In Model 2, high-tech enterprises have a stronger awareness of technological innovation than non-high-tech enterprises. Therefore, in order to distinguish these two mutually exclusive types of enterprises, Model 2 is used to enhance the rigor of the paper's demonstration. Similar to Model 1, if the coefficient of the interaction term of ESG Performance (ESG) and High-Tech Enterprise (HTE) is significantly positive with other variables controlled, it can be indicated that Hypothesis H2 is valid.

4. Empirical Analysis

4.1 Descriptive Statistics

Table 2. Descriptive Statistics

Name	N	Mean	SD	Med	Min	Max
IPI	24114	2.120	2.498	1.950	0.000	16.430
ESG	24114	1.339	0.301	1.385	0.000	2.045
HTE	24114	0.478	0.498	0.000	0.000	1.000
AGE	24114	2.981	0.420	2.128	1.611	4.902
ADR	24114	0.425	0.182	0.502	0.119	0.911
ROA	24114	0.027	0.058	0.027	-0.279	0.168

Table 2 presents the descriptive statistical results of the main variables. The mean value of Innovation Input Intensity (IPI) is 2.12, with the maximum and minimum values of 16.43 and 0.000 respectively. It shows that even after winsorizing the top 1% of extreme values of innovation input intensity, there are still significant differences in innovation input intensity among sample enterprises, which also reflects the imbalance of innovation input of Chinese enterprises. The mean value of ESG Performance (ESG) is 1.339, and a larger value indicates better corporate ESG performance. The mean value of High-Tech Enterprise (HTE) is 0.478, which shows that the sample distribution is relatively balanced in the research sample of this paper, providing a good data foundation for the subsequent analysis of industrial heterogeneity.

4.2 Regression Results

Table 3. Regression Results

Variable	(1) IPI	(2) IPI	(3) IPI
ESG	1.022***(5.455)	2.122***(13.71)	1.624***(10.71)
HTE	—	—	5.115***(2.81)
ESG×HTE	—	—	1.242***(4.031)
AGE	0.120*(1.711)	0.123*(1.442)	0.123*(1.442)
ADR	-7.211***(-18.010)	-2.457***(-9.112)	-2.457***(-9.112)
ROA	3.284**(2.673)	2.221**(1.925)	2.221**(1.925)
Constant	1.924*(1.783)	-14.25**(-13.94)	-9.390**(-9.456)
YEAR	NO	YES	YES
N	24114	24114	24114
Adj-R^2	0.103	0.452	0.471
F	121.26	131.72	116.22

Note: 1. *p<0.1, **p<0.05, ***p<0.01; t-statistics are in parentheses.

2. (1) without year fixed effects; (2) with year fixed effects; (3) with moderating effect.

It can be seen from Table 3 that the regression coefficients of ESG Performance (ESG) are 1.022 and 2.122 respectively, both significant at the 1% level. This shows that after considering other factors, corporate ESG performance can significantly improve R&D input intensity. The coefficient of Firm Age (AGE) is positive, indicating that enterprises established for a longer time have higher innovation input intensity. This may be because mature enterprises have accumulated more resources (funds, technology, talents) and have the ability to continuously invest in R&D; at the same time, enterprises with long-term survival have often formed a stable innovation mechanism and can internalize innovation into organizational practices. The coefficient of Asset-Liability Ratio (ADR) is negative, indicating that high debt restrains innovation input. The coefficient of Return on Assets (ROA) is significantly positive, indicating that the higher the enterprise's return on assets, the higher the innovation input intensity, and profitability is an important financial support for corporate innovation. This regression shows that the improvement of ESG performance plays an important role in the long-term development of enterprises, which is conducive to improving the scientific and technological innovation environment of enterprises, increasing their innovation input and promoting the improvement of their core competitiveness. Therefore, Hypothesis H1 is verified. The coefficient of the interaction term of ESG Performance and High-Tech Enterprise is 1.242, significant at the 1% level, which shows that high-tech enterprises play a positive moderating role, and the positive incentive effect of good ESG performance on their innovation input is more significant. Therefore, Hypothesis H2 is verified.

4.3 Robustness Test

Table 4. Robustness Test

Variable	(1) IPI	(2) IPI	(3) IPI
ESG	0.449***(3.033)	0.501***(2.589)	0.501***(2.589)
HTE	—	—	2.424**(5.982)
ESG×HTE	—	—	0.064***(2.232)
Constant	-4.886**(-3.160)	-5.885**(-3.787)	-5.885**(-3.787)
YEAR	YES	YES	YES
N	24114	24114	24114
Adj-R^2	0.135	0.092	0.092
F	112.930	110.720	110.720

Note: *p<0.1, **p<0.05, ***p<0.01; t-statistics are in parentheses.

It can be seen from Table 4 that the coefficients of the core independent variable ESG and the interaction term ESG×HTE are both positive and significant at the 1% level, which is consistent with the main regression results, indicating that the research conclusions of this paper are robust.

5. Conclusions

By screening and sorting out the research samples of most A-share listed companies on the Shanghai Stock Exchange of China from 2008 to 2024, this paper empirically tests the impact of ESG performance on corporate innovation input intensity, and discusses separately whether the enterprise is a high-tech enterprise.

Through rigorous analysis, this paper draws the following conclusions:First, ESG performance can significantly improve enterprises' R&D input intensity, and this conclusion still holds after controlling for year fixed effects. Second, from the analysis of industrial attribute differences, it is found that the positive impact of ESG performance on innovation input intensity is more significant in high-tech enterprises.

This paper also has some limitations. It does not consider the dimensional impacts of environment, society and governance of ESG, and the selection of control variables can be further enriched.

It is worth noting that this paper draws the above two conclusions from a macro perspective based on 24114 sets of annual enterprise data. In the specific micro-practice of enterprises, it is necessary to analyze specific problems according to the specific internal and external conditions of enterprises.

For high-tech enterprises, fulfilling social responsibility should be placed in a strategic

position important to their development. This is not only related to shaping the enterprise's own values, but also a crucial aspect of building long-term competitiveness in a rapidly changing market environment. Enterprises need to comprehensively strengthen the transparency and standardization of ESG information disclosure, ensuring that their performance in environmental, social, and governance aspects can be accurately and timely measured and presented. At the same time, they should proactively incorporate ESG concepts systematically into their long-term innovation strategies and daily operational decisions, making them an inherent criterion driving technology research and development, product design, and management processes. While actively fulfilling various social responsibility commitments, high-tech enterprises should also focus on the brand communication of related practices and achievements, shaping an image of responsible innovators through effective communication, thereby continuously enhancing the enterprise's social credibility and brand reputation, and ultimately strengthening its endogenous driving force for sustainable development, forming a virtuous cycle where commercial value and social value mutually promote each other.

For enterprises without high technologies, actively promoting ESG practices holds more direct practical value, especially in improving the financing environment. By establishing a credible and verifiable ESG management and disclosure system, enterprises can clearly demonstrate to investors and financial institutions their sound governance structure, robust environmental risk control capabilities, and positive social contributions. This demonstration is not only for image building but also signals to the market about the enterprise's long-term stable operating capabilities, which helps significantly reduce the enterprise's financing costs and broaden diversified financing channels. The resulting financial advantages can gradually accumulate necessary capital reserves for important investments such as technological upgrading, capacity optimization, and product innovation in the future, laying a solid financial foundation for the enterprise's transformation and development.

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