

The Impact of ESG Ratings on Enterprise Innovation--- Internal and External Governance

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Abstract. In recent years, with the enhancement of the awareness of sustainable development, ESG has been widely adopted by global regulators and institutional investors, bringing new connotations to enterprise management and strategic decision-making. However, there is still a research gap on the internal mechanism of ESG promoting enterprise innovation. Based on the data of China's A-share listed firms from 2011 to 2021, this paper examines the impact of environmental, social and governance (ESG) on enterprise innovation and the moderating effect of CEO's information technology background from the perspective of internal and external governance. The research shows that ESG ratings significantly promote enterprise innovation, and CEO's information technology background strengthens this effect. Further analysis of the influencing mechanisms shows that ESG ratings primarily enhance internal control quality through internal governance channels and promote enterprise innovation by improving analyst coverage through external governance channels. The research reveals that government should improve the ESG rating mechanism, and enterprises should actively participate in ESG ratings. Furthermore,when implementing a sustainable development strategy, enterprise should consider the information technology background of their professional managers.This paper makes up for the lack of research in related fields and provides an important supplement to the research on ESG and enterprise innovation.

Keywords: ESG rating ; enterprise innovation ; CEO 's information technology

1. Introduction

In recent years, some scholars have begun to attach their attention to the impact of enterprise ESG ratings on enterprise innovation activities (Qi et al., 2020; Fang and Hu, 2023), and they have found that ESG ratings can positively affect enterprise innovation activities, but only through internal effects, such as mitigating financing constraints (Zhai et al., 2022) and agency costs (Tang, 2022), to promote enterprise innovation. However, apart from internal effects, enterprise also experience external governance effects, and these two mechanisms both differ and complement each other. Therefore, it can be inferred that the impact of ESG ratings on enterprise innovation should result from the combined effects of internal and external effects. This study empirically examines the relationship between ESG ratings and enterprise innovation from the perspectives of internal and external governance.

2. Formulation of research hypotheses

2.1 Impact of ESG ratings on enterprise innovation

ESG rating is a comprehensive evaluation of the sustainable development performance of enterprises from the following three dimensions: environment, society and governance. The ESG activities are integrated into the enterprise governance system. The information of ESG is disclosed to support the business activities in management decision-making and investor decision-making. From the perspective of management, ESG rating reflects the ability of enterprises to create comprehensive value for all parties in its operational process (Sheng et al., 2023). Environmental

information disclosure in ESG evaluation can urge enterprises to make efforts in the field of environmental protection and provide external motivation for enterprises to realize green transformation (Chris et al., 2018). The disclosure of social responsibility information in the ESG rating will affect the credibility of the firm. When the firm takes social responsibility as a business strategy, it is necessary to innovate the business model; moreover, taking social responsibility helps enterprises to establish connections with external stakeholders (Chen et al., 2020). The disclosure of enterprise governance information in the ESG rating reflects an enterprise's governance level. On the issues of shareholder agency, balance of interests, long-term and short-term coordination, entrepreneurs have the ability to handle the issues properly, so as to ensure their enterprises in a harmonious, united and stable situation, and provide environmental support for enterprise innovation. Based on the above analysis, hypothesis 1 is: H1: ESG ratings can promote enterprise innovation.

2.2 Internal governance channels

The ESG concept holds that enterprises should take the road of sustainable development. In order to obtain the long-term development ability, enterprises must carry out effective internal governance. The disclosure of internal governance information in ESG rating provides an external driving force for enterprise innovation. Long-term investors will pay attention to whether the internal governance ability of the enterprise matches its sustainable development goal, and will pay attention to the relationship between the internal governance level of the enterprise and the current operating performance, so as to judge whether it has growth potential. Enterprises with higher ESG rating are more likely to obtain external financing, thus providing capital support for enterprise innovation. Thus, hypothesis 2 is proposed:

H2: ESG ratings are conducive to improving the quality of internal controls and thus promoting enterprise innovation.

2.3 External governance channels

According to the division of governance subjects, the external governance channels of enterprises include government governance, analyst attention, investor attention, public supervision and so on. Compared with other external governance methods, analysts' analysis of the enterprise's objectivity, professionalism and prudence is recognized by investors. The information disclosure in ESG ratings provides rich content for analysts and facilitates the work of analysts, thus attracting more analysts to pay attention to enterprises that participate in ESG ratings. The analyst's interpretation of professional information effectively alleviates the problem of information asymmetry, especially before the enterprise innovation forms an absolute competitive advantage. Enterprises can not disclose too much innovation-related information, but they can disclose relevant information. As a third party, the analyst's role aligns with that of the investor, and their analysis and prediction of the problem can resonate with investors, thereby benefiting the enterprises in obtaining innovative investments (Chen, 2017). Based on the above analysis, hypothesis 3 is:

H3: ESG rating is conducive to improving analyst participation and promoting enterprise innovation.

2.4 The moderating role of the CEO's information technology background

CEOs with background in information technology are familiar with various information technology and information system operations and processes. They pay closer attention to emerging trends in information technology development and have a clearer understanding and awareness of innovation risks and benefits. When planning enterprise strategy, CEOs with information technology background are more willing to adopt information technology means that fit their previous cognition to solve the current development bottleneck of enterprises (Liu et al., 2023).

On one hand, CEO's information technology background can accelerate the circulation and sharing of data elements. It can break the information barriers and estrangement between enterprises

and different stakeholders. On the other hand, the CEO's IT background can enhance the company's resource allocation capabilities and improve the company's digital capabilities. At the same time, it can create an effective information ecological governance system and form a community of shared interests and common governance. The final hypothesis is:

H4: CEO's information technology background can strengthen the role of ESG rating in promoting enterprise innovation.

3. Research design

3.1 Sample selection and data sources

The researchers collected data from A-share listed firms in China from 2011-2021. Since the existing data cannot be interfered by other factors, the samples are processed as follows: (1) enterprises suffered losses for two consecutive years are excluded, so are ST and *ST; (2) financial companies are excluded; (3) incomplete data are excluded. A final sample of 23,519 observations was obtained. Since the main variables in this study are continuous variables, the variables of interest are reduced-tailed at the 1 % and 99 % levels in order to exclude the effect of outliers. The ESG ratings data of this study were obtained from the ratings provided by Hexun, the ratings were obtained from Wind database, enterprise innovation was obtained from CSMAR database, internal control quality was obtained from DIB database, and the rest of the variables were obtained from CSMAR database.

3.2 Definition of variables

3.2.1 Enterprise innovation

The practice of Yang's (Yang, 2021) is referred. Two methods to measure enterprise innovation are taken in this study. The natural logarithm was adopted to measure enterprise innovation: 1 natural logarithm of the number of patent applications (Patent) and the number of invention patent applications plus 1 natural logarithm (InoPatent) .

3.2.2 ESG ratings

The ESG rating of the firm rated all listed firms as 9 levels, and the ratings from low to high were C, CC, CCC, B, BB, BBB, A, AA, and AAA respectively. The ESG level is increased with the rating value increased. The ESG level of the enterprise was given from low to high by numbers 1-9.

3.2.3 CEO information technology background

When a CEO has educational experience or practitioner experience related to enterprise information technology management and information technology, the CEO is considered to have an information technology background and assigned a value of 1, otherwise it is 0 (Li et al. 2020) .

3.2.4 Control variables

Based on the existing literature (Wang and Peng, 2022), the control variables introduced in this paper include enterprise size (Size), enterprise age (Age), return on total assets (Roa), enterprise value (TobinQ), growth rate of operating income (Growth), operating cash flow (Cf), shareholding ratio of the largest shareholder (Top1), and duality (Dual). In addition, this study also controls the annual fixed effect and industry fixed effect.

3.3 Model setup

This study adopts regression model (1) to test the effect of ESG ratings on enterprise innovation. The specific regression model is as follows.

$$\text{Innovation}_{it} = \alpha_0 + \alpha_1 \text{ESG}_{it} + \text{Controls}_{it} + \text{Year} + \text{Ind} + \varepsilon_{it} \quad (1)$$

$$\text{Innovation}_{it} = \alpha_0 + \alpha_1 \text{ESG}_{it} + \alpha_2 \text{CEOIT}_{it} + \alpha_3 \text{ESG}_{it} * \text{CEOIT}_{it} + \text{Controls}_{it} + \text{Year} + \text{Ind} + \varepsilon_{it} \quad (2)$$

In the formula, $Innovation_{it}$ is the dependent variable, including Patent and InoPatent, and ESG_{it} is the independent variable denoting the ESG rating received by firm i in year t , the $CEOIT_{it}$ denotes the CEO's IT back, and $Controls_{it}$ is the control variable of this study. Model (2) tests the moderating effect of CEO's IT background, if the ESG coefficient is significantly positive and the $ESG_{it} * CEOIT_{it}$ coefficient is also significantly positive, then the positive moderating effect of CEO's IT background is significant. In addition, to control for some unobservable factors that can't change over time, this study controls for industry fixed effects and time fixed effects further.

4. Empirical analysis

4.1 Basic regression analysis

Table 1 reports the regression results of ESG rating and enterprise innovation. Column (1) (3) controls the industry fixed effect and time fixed effect, and Column (2) (4) adds other control variables that may affect the level of enterprise innovation. The results show that ESG rating can significantly promote enterprise innovation. Taking Column (2) as an example, the ESG coefficient is 0.446, which is significantly positive at the 1 % level, indicating that the ESG rating significantly increases the number of enterprise patent applications. Column (4) shows that the ESG coefficient is 0.377, which is significantly positive at the 1 % level, indicating that the ESG rating significantly increases the number of enterprise invention patent applications. The results indicate that the increase of enterprise ESG rating will increase the natural logarithm of enterprise patent application by 44.6 %, and increase the natural logarithm of invention patent application by 37.7 %. H1 is verified.

Table 1 Impact of ESG ratings on firms' innovation

	(1)	(2)	(3)	(4)
	Patent	Patent	InoPatent	InoPatent
ESG	0.630***	0.446***	0.555***	0.377***
	(34.855)	(24.336)	(33.908)	(22.983)
Size		0.308***		0.319***
		(29.042)		(33.184)
Age		-0.286***		-0.201***
		(-17.317)		(-13.814)
Roa		1.374***		1.091***
		(8.076)		(7.279)
TobinQ		0.023***		0.049***
		(2.726)		(6.386)
Growth		-0.029***		-0.011
		(-2.986)		(-1.254)
Cf		0.035		0.181***
		(0.464)		(2.601)
Top1		-0.003***		-0.003***
		(-4.185)		(-5.046)
Dual		-0.036*		-0.014
		(-1.817)		(-0.752)
YEAR FE	Yes	Yes	Yes	Yes
IND FE	Yes	Yes	Yes	Yes
cons	-4.099***	-8.748***	-3.698***	-8.948***
	(-27.005)	(-34.807)	(-27.258)	(-38.968)
N	23516	23516	23516	23516
r ²	0.349	0.384	0.281	0.327
r ² a	0.346	0.381	0.278	0.324

Note: *, **, and *** represent significant at the 10%, 5%, and 1% levels, respectively; The t-values within parentheses are adjusted robustly by robust heteroscedasticity; same below.

4.2 The moderating role of the CEO's information technology background

Table 2 shows the regression results of model (2). The regression coefficient of ESG * CEOIT in column (1) is significantly positive at 1% significance level, and the regression coefficient of ESG is significantly positive at 1% significance level, indicating that with the continuous improvement of CEO's information technology background, the positive incentive effect of ESG rating on the number of patent applications is greater. In column (2) of table 4, the cross-multiplication of ESG and CEO's information technology background (ESG * CEOIT) is significantly positive at the 1% significance level, and the regression coefficient of ESG is significantly positive at the 1% significance level, indicating that the CEO's information technology background positively regulates the promotion effect of ESG on the number of enterprise invention patent applications. It is verified that hypothesis H4, the degree of information technology background of enterprise CEO can enhance the promotion effect of ESG rating on enterprise innovation.

Table 2 Moderating effect of CEO's information technology background

	(1)	(2)
	Patent	InoPatent
ESG	0.189***	0.157***
	(20.864)	(19.504)
CEOIT	-0.503***	-0.441***
	(-3.467)	(-3.245)
ESG*CEOIT	0.165***	0.161***
	(4.979)	(5.062)
Controls	Yes	Yes
YEAR FE	Yes	Yes
IND FE	Yes	Yes
cons	-6.807***	-7.198***
	(-28.015)	(-31.655)
N	23516	23516
r ²	0.384	0.331
r ² _a	0.382	0.328

4.3 Stability tests

4.4.1 Lagged effects of explanatory variables

Considering that the innovation proxy variable used in this study is patent data, innovation agents driven by ESG ratings have a longer R&D time to submit patent applications. Therefore, the numbers of patents and invention patent applications are delayed by one period and two periods respectively to express the innovation behavior, as shown by the results in columns (1) and (3) of Table 3. The coefficient of the explanatory variable number of patent applications lagged by one period (L. Patent) is 0.441, which is significant and positive at the 1% level, and the coefficient of the explanatory variable number of invention patents lagged by one period (L.Inopatent) has a coefficient of 0.377 which is significantly positive at the 1% level. The results in columns (2) and (4) of Table 6 show that the coefficient of ESG for the explanatory variable lagged by two periods is also significantly positive at the 1% level.

Table 3 Lagged effects of explanatory variables

	(1)	(2)	(3)	(4)
	L. Patent	L2.Patent	L. InoPatent	L2.InoPatent
ESG	0.441***	0.437***	0.377***	0.371***
	(21.997)	(20.113)	(20.854)	(19.087)
cons	-8.501***	-8.251***	-8.814***	-8.659***
	(-30.704)	(-27.039)	(-34.807)	(-31.003)
Controls	Yes	Yes	Yes	Yes
YEAR FE	Yes	Yes	Yes	Yes
IND FE	Yes	Yes	Yes	Yes
N	19018	15812	19018	15812
r ²	0.394	0.394	0.336	0.337
r ² a	0.391	0.391	0.332	0.333

4.4.2 Replacement of measures of explanatory variables

Regressions are conducted using enterprise ESG ratings data provided by Bloomberg Consulting (ESG_PB) to replace the ESG ratings data of CSI firms (ESG) used in the benchmark model. The main function is still significant.

4.4.3 Change of sample year

In order to eliminate the estimation bias that may be caused by a specific year, this study continues to subdivide the regression years into two groups on the original period 2011-2021. As shown in table 4, (1) and (2) are listed in the 2011-2016 return year group, and (3) and (4) are listed in the 2017-2021 return year group; this shows that in different regression years, the impact of ESG rating on enterprise innovation promotion is still significant.

Table 4 Year of change in sample statistics

	(1)	(2)	(3)	(4)
	Patent	InoPatent	Patent	InoPatent
ESG	0.362***	0.302***	0.495***	0.418***
	(13.068)	(12.483)	(20.209)	(18.836)
cons	-8.517***	-8.648***	-8.629***	-9.017***
	(-22.961)	(-25.723)	(-24.490)	(-27.891)
Controls	Yes	Yes	Yes	Yes
YEAR FE	Yes	Yes	Yes	Yes
IND FE	Yes	Yes	Yes	Yes
N	11258	11258	12258	12258
r ²	0.403	0.339	0.368	0.316
r ² a	0.398	0.334	0.363	0.311

4.4.4 Instrumental variables approach

Based on the research of Li Zhibin et al. (2022), this paper chooses the industry mean of Hexun ESG rating (Mean-ESG) as ESG. In addition, the Kleibergen-Paap rk LM test rejects the null hypothesis of insufficient identification of instrumental variables at the 1 % significance level, indicating that the instrumental variables constructed are identifiable. The statistics of the Kleibergen-Paap rk Wald F test are greater than the critical value of the Stock-Yogo test at the 10% level, rejecting the null hypothesis of weak identification of instrumental variables.

5. Mechanism of action test

5.1 Internal governance mechanisms --- mediating effects of internal controls

Effective implementation of internal control can ensure the quality of enterprise financial reporting disclosure and reduce the possibility of enterprise violations, thereby improving enterprise performance and meeting the funding needs of innovation activities. At the same time, ESG ratings are closely related to the quality of internal control. firms with good ESG performance usually have better internal control systems. Referring to the common practice of the existing literature, the internal control quality of listed firms is measured by using the Dibo internal control index plus 1 in the Dibo internal control and risk management database (Chen and Fang 2018) . On the basis of model (1), model (3) (4) is constructed to test the mediation effect of internal mechanisms.

$$ICE_{it} = \alpha_0 + \alpha_1 ESG_{it} + Controls_{it} + Year + Ind + \varepsilon_{it} \quad (3)$$

$$Innovation_{it} = \alpha_0 + \alpha_1 ESG_{it} + \alpha_2 ICE + Controls_{it} + Year + Ind + \varepsilon_{ikt} \quad (4)$$

The regression results are shown in Table 4. Column (1) shows that the ESG coefficient is 0.164, which is significantly positive at the 1% level, indicating that ESG can promote the improvement of internal control quality. Columns (2) and (3) show that ICE is significantly positive at the 10% and 1% levels, respectively. That is to say, ESG rating can promote enterprise innovation by improving the quality of internal control, so as to verify H2.

5.2 Mediating effects of external mechanism governance-analyst coverage

Analyst coverage behavior has a positive effect on reducing information asymmetry. For one side, analysts provide effective and timely information for users by their professional analytical ability, in an effort to ensure the effective interpretation of the value information of innovation projects then to promote innovation investment. On another side, the continuous tracking of innovation activities by analysts can play the role of external supervision and make up for the lack of internal supervision. Referring to the common practice of the existing literature, the number of analysts in the natural annual tracking firm plus 1 is used to measure the analyst coverage of listed firms (Wei et al., 2020). On the basis of model (1), model (5) (6) are constructed to test the mediation effect of external mechanisms.

$$Coverage_{it} = \alpha_0 + \alpha_1 ESG_{it} + Controls_{it} + Year + Ind + \varepsilon_{it} \quad (5)$$

$$Innovation_{it} = \alpha_0 + \alpha_1 ESG_{it} + \alpha_2 Coverage_{it} + Controls_{it} + Year + Ind + \varepsilon_{ikt} \quad (6)$$

The regression results are shown in Table 5. Column (1) shows that ESG coefficient is 0.164, which is significantly positive at 1% level, indicating that ESG can contribute to the quality of internal control. Columns (2) and (3) show that Coverage are both significantly positive at 1% level. That is to say, ESG rating can promote enterprise innovation by increasing analyst coverage, thus verifying H3.

Table 5 Mechanism tests

	(1)	(2)	(3)	(4)	(5)	(6)
	ICE	Patent	InoPatent	Coverage	Patent	InoPatent
ESG	0.164*** (10.239)	0.447*** (22.931)	0.374*** (21.530)	0.195*** (16.423)	0.420*** (22.938)	0.352*** (21.476)
ICE		0.019* (1.825)	0.023*** (2.660)			
Coverage					0.133*** (13.280)	0.130*** (14.421)

Controls	Yes	Yes	Yes	Yes	Yes	Yes
YEAR FE	Yes	Yes	Yes	Yes	Yes	Yes
IND FE	Yes	Yes	Yes	Yes	Yes	Yes
_cons	4.850***	-8.863***	-9.119***	-11.635* **	-7.198***	-7.439***
	(25.658)	(-32.965)	(-37.246)	(-73.353)	(-25.962)	(-29.627)
N	23516	23516	23516	23516	23516	23516
r2	0.086	0.394	0.336	0.441	0.389	0.333
r2_a	0.082	0.391	0.333	0.439	0.386	0.330

6. Conclusions and implications

6.1 Conclusions

Based on the data of China's A-share listed firms from 2011 to 2021, the impact of ESG rating on enterprise innovation is examined. The moderating effect of CEO's information technology background is analyzed. Besides, the mediating role of internal control quality and analyst coverage is explored. The results show that ESG rating significantly improves enterprise innovation, and CEO's information technology background will have a positive moderating effect. The internal and external mechanism test shows that the promotion effect of ESG rating on enterprise innovation is related to effective internal control and sufficient analyst coverage.

6.2 Implications

The ESG information disclosure system should be improved to guide and encourage enterprises to participate in ESG ratings. There's a need to establish a fair and reasonable ESG rating results reward and punishment mechanism, encourage enterprises to disclose ESG information, and provide stakeholders with authentic and effective decision-making basis.

Enterprise innovation should consider the information technology background of professional managers in the era of digital economy. Professional managers with information technology background can better fit the current economic development trend in strategic planning, resource integration and factor allocation, so as to ensure innovation in the right direction.

Regulatory authorities should enhance the regulatory oversight on the authenticity of ESG information disclosed by enterprises. Whether analysts quoting ESG rating information is scientific and objective, whether there is distortion or exaggeration in the information, whether it has caused adverse effects on society, information transmission platforms should be urged to conduct effective information audits.

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References

- [1] Qi Zhang, Lawrence Loh, Weiwei Wu. How do Environmental, Social and Governance Initiatives Affect Innovative Performance for enterprise? How do Environmental, Social and Governance Initiatives Affect Innovative Performance for enterprise Sustainability? Sustainability, 2020, 12(8).
- [2] Fang Xianming, Hu Ding. enterprise ESG Performance and Innovation-Evidence from A-share Listed Companies[J]. Economic Research, 2023, 58(02):91-106.

- [3] Zhai Yuming,Cai Zhenghuan,Lin Han,Yuan Ming,Mao Ye,Yu Mingchuan. Does better environmental, social, and governance induce better enterprise green innovation: The mediating role of financing constraints[J]. *enterprise Social Responsibility and Environmental Management*,2022,29(5).
- [4] Tang Hua. The Effect of ESG Performance on enterprise Innovation in China: The Mediating Role of Financial Constraints and Agency Cost[J]. *Sustainability*,2022,14(7).
- [5] Sheng Mingquan,Yu Lu,Wang Wenbing.ESG disclosure and stock price crash risk[J]. *Journal of Guizhou University of Finance and Economics*,2023,No.223(02):32-41.
- [6] Li Chao,Ba Shusong,Ma Kejia,Xu Yueling,Huang Wenli,Huang Niyuan. ESG Rating Events, Financial Investment Behavior and enterprise Innovation[J]. *Economic Analysis and Policy*,2023,77.
- [7] Chris Ball,George Burt,Frans De Vries,Erik MacEachern.How environmental protection agencies can promote eco-innovation: the prospect of voluntary reciprocal legitimacy[J]. *Technological Forecasting & Social Change*,2018,129.
- [8] Chen Yufen,Jin Bixia,Ren Yi. Influence mechanism of enterprise social responsibility on technological innovation performance--Based on the mediating effect of social capital[J]. *Research Management*,2020,41(09):87-98.
- [9] Liu Xilu,Chen Zhijun,Ma Pengcheng. Information technology background CEO and enterprise digital transformation[J]. *China Soft Science*,2023(01):134-144.
- [10] Jinkun Yang. enterprise Social Responsibility Disclosure and Innovation Performance: An Empirical Study of Chinese Listed Companies in the "Mandatory Disclosure Era"[J]. *Science and Science and Technology Management*,2021,42(01):57-75.
- [11] Li Ruijing,Dang Suting,Li Baixing,Yuan Rongli.CEO's information technology background and the quality of enterprise internal control[J]. *Auditing Research*,2022(01):118-128.
- [12] Wang Zhi,Peng Baichuan. The impact of enterprise ESG performance on innovation performance[J]. *Statistics and Decision Making*,2022,38(24):164-168.
- [13] Zhi-Bin Li,Yu-Meng Shao,Zong-Ze Li,Min-Shi Li.ESG disclosure,media monitoring and enterprise finance constraints[J]. *Scientific Decision Making*,2022(07):1-26.
- [14] Zuohua Chen,Hongxing Fang. Financing constraints, internal control and enterprise tax avoidance[J]. *Management Science*,2018,31(03):125-139.
- [15] WEI Zhihua,XIA Taibiao,WANG Huiping. Affiliated Transactions, Analyst Behavior and Stock Price Synchronicity-An Empirical Study Based on Chinese Listed Companies[J]. *Accounting and Economic Research*,2020,34(05):3-27.