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AI Adoption and Corporate ESG Performance: Evidence from Chinese Listed Companies

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Abstract: With the rapid development of artificial intelligence technology and increasing attention to corporate environmental, social, and governance performance, this study investigates the impact of AI adoption on firms' ESG performance in the Chinese context. Based on the sample of Chinese A-share listed companies from 2009 to 2020, this paper uses the method of textual analysis based on annual reports to examine how AI implementation affects corporate ESG ratings. The results indicate that the extent of AI-related information disclosed in corporate annual reports is significantly and positively related to their ESG ratings. Further analysis shows that this positive relationship holds after controlling for firm characteristics and conducting various robustness tests using alternative measures of AI adoption. The research enriches the literature on the determinants of ESG performance by providing new evidence on the role played by AI technology in enhancing corporate sustainability, and offers practical implications for corporate managers and policymakers on how to use AI technology in improving ESG performance and achieving the goals of sustainable development.

Keywords: artificial intelligence, ESG performance, textual analysis, digital transformation, sustainable development.

1. Introduction

The rapid development of AI technology is profoundly changing the way enterprises operate and their business models. According to the International Data Corporation (IDC), global AI spending reached $154 billion in 2023 and is expected to grow to $225 billion by 2025, showing great potential for development. However, the application of AI technology is two-sided, and there are many challenges, such as the costs associated with the consumption of computing resources, social equity issues caused by algorithmic bias, and governance challenges such as data security and privacy protection. Therefore, whether enterprises should use AI technology has become an important topic worthy of in-depth discussion.

Existing literature examines corporate ESG performance from two main aspects: one is to explore the influencing factors of ESG performance, and the other is to study the economic consequences of ESG performance on firms. In terms of ESG influencing factors, scholars have found that factors such as firm characteristics, corporate governance and external environment affect firms' ESG performance. For example, Chen et al. found that firm size and profitability are significantly and positively correlated with ESG ratings, while Rutskiy found that the level of corporate governance is

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an important factor affecting ESG ratings [1] [2]. However, there is a relative lack of research on the impact of AI technology applications on firms' ESG performance, especially the lack of empirical research in the context of emerging markets.

To fill this research gap, this paper takes Chinese A-share listed companies from 2009 to 2020 as a sample and uses textual analysis to examine the impact of corporate AI technology application on their ESG performance. It is found that the degree of AI-related information disclosure in firms' annual reports is significantly and positively related to their ESG ratings, a finding that remains robust after controlling for firm size, financial performance, and other characteristic variables. To ensure the reliability of the findings, the paper uses two different text analysis metrics, AI-related word frequency and sentence count, to conduct robustness tests, and the results remain consistent.

The marginal contributions of this paper are mainly three: first, this paper is the first to systematically examine the impact of AI technology application on corporate ESG performance, enriching the relevant literature on corporate ESG influencing factors, and providing important empirical evidence on how corporations can enhance their sustainability through digital transformation [3]. Second, this paper adopts textual analysis to construct the measurement index of the degree of enterprise AI application, which expands the research perspective of measuring the level of enterprise AI application and provides new research ideas for subsequent related studies. Third, the findings of this paper are of great practical significance to corporate managers and policy makers, suggesting that corporations can enhance their ESG performance by strengthening the application of AI technology to gain a competitive advantage in sustainable development [4].

The rest of the paper is organized as follows: the second part is the literature review and institutional background, the third part presents the hypotheses development, the fourth part introduces the research design, the fifth part analyzes the empirical results, and the sixth part concludes the study.

2. Literature Review and Institutional Background

2.1. Factors Affecting ESG

Existing ESG-related research focuses on two main areas: determinants of ESG performance and the consequences of ESG performance on firms.

As for studies on determinants of ESG, Rutskiy focuses on the efficiency factors affecting the ESG ratings of firms, and through a case study of large Russian firms concludes that return on capital, return on equity, and carbon dioxide emissions are positively correlated with ESG ratings, while revenue growth rates are negatively correlated with ESG ratings [2]. Chen et al. investigate how artificial intelligence influences corporate ESG performance using data from Chinese listed companies during 2007-2022 [1]. They find that AI development significantly enhances firms' ESG performance, particularly through improving total factor productivity and R&D expenditure. The effect is more pronounced in non-state-owned enterprises, firms without executives with overseas background, technology and capital-intensive companies, and those located in eastern and central regions. Khaw et al. study what factors affect companies' ESG performance by analyzing research papers from the past ten years [5]. Through examining publication patterns and reviewing literature, they find that things like how companies are run, how they work with stakeholders, and what rules they follow all impact ESG performance. Their study shows that different regions focus on different ESG aspects - developed countries care more about environmental issues, while developing countries pay more attention to governance matters.

Studies on consequences of ESG suggest that AI adoption and digital transformation significantly enhance ESG implementation while creating positive impacts on sustainable development and employment.

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As for studies on AI's role in ESG enhancement, Taleb, Mushtaq & Kadhum, Hussein. focus on how AI technologies promote ESG practices, and through their systematic review conclude that AI improves sustainable development and social welfare through enhanced data analysis, environmental monitoring, and decision-making, while suggesting balanced regulations that foster innovation and mitigate risks [6].

As for research on AI in financial systems, Engel focuses on AI's transformation of payment systems in non-bank financial institutions, and through analysis of industry practices and emerging trends concludes that AI enhances payment validation with 15-20 percent reduction in rejection rates, while demonstrating primary benefits in task automation and embedded finance despite governance challenges [7].

As for studies on ESG and workforce dynamics, Du et al. focus on the relationship between ESG implementation and employment expansion in China's digital transformation era, and through analysis of 14-year data (2009-2022) conclude that digital capabilities amplify ESG practices' employment benefits across enterprise categories and sectors, while providing a three-dimensional framework integrating ESG, employment, and digital transformation metrics for sustainable business development [8].

3. Hypotheses Development

There is a positive relationship between the adoption of AI technologies by firms and their ESG performance. Specifically, AI adoption may influence ESG performance through various mechanisms, including but not limited to those outlined below.

First, at the environmental level, AI technologies can contribute to better attainment of the set goals a company has in terms of the environment through optimizing energy use efficiency, real-time monitoring of carbon emissions, and the prediction of environmental risks. For example, Microsoft was able to apply AI systems in its data centers that were analyzing millions of points in real time and automatically adjusting the cooling equipment. This managed to cut their energy use by 40%. It enables companies to monitor enterprise energy consumption patterns in real time, find inefficient uses of energy, and automatically optimize production processes by using intelligent sensors and algorithms. Big data analytics can forecast the impact brought about by weather changes to the production activities of some relevant enterprises more precisely and make preparation in advance, which improves the coping ability and reduces the environmental risks caused by extreme weather. Therefore, AI can go a long way in reaching the environmental objectives of an organization and make energy utilization more efficient and helpful.

At the social level, AI can promote the transparency of supply chain management, improve the working environment for employees, and enhance community-company relationship management. With the addition of blockchain and AI, labor conditions, sources of raw materials, and other information related to social responsibility flowing into the supply chain can be more effectively traced by companies. A prime example would be IBM's Watson AI system, which helps HR departments analyze the recruitment process for potential bias and ensures nondiscriminatory hiring by scrutinizing job descriptions and resume-screening criteria to identify gender or racial discrimination. Intelligent human resource management systems can also make decisions regarding the evaluation and promotion of employees in a more just and objective manner than the human bias. Also, it aids in translating and responding properly to the community's demands with technologies such as social media data monitoring, thereby enabling the smoothing of relations with all stakeholders. AI usage will afford the company an ability to meet demands by all kinds of stakeholders.

In terms of corporate governance, AI technology will be able to help management make more informed decisions with more comprehensive data support and risk alerts. For example, JPMorgan

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Chase uses AI technology in compliance risk monitoring to automatically analyze transaction data and communication records for suspicious activities, thus enhancing compliance management efficiency. These can be analyzed for potential risks and issues by machine learning algorithms applied to huge sources of information such as market data, news reports, and social media data. An Intelligent Compliance System can monitor, on its own, corporate operations that are carried out with compliance to their respective laws and regulations. This would further reduce compliance risk. Meanwhile, AI-assisted decision support systems can make more objective and comprehensive decision-making suggestions for management committees and improve the effectiveness of corporate governance. It is thus known that artificial intelligence can provide enterprise management with a wider range of information sources that can be helpful for their decision-making.

From the perspective of long-term economic benefits, applying AI in ESG management may bring impacts with positive directions to enterprises in many ways. Through the introduction of intelligent energy management systems, automatic monitoring and optimization can be achieved for both energy and cost consumption, which will lower energy expenses and operating costs. The application of intelligent monitoring and processing systems will be able to help enterprises solve problems in a timely manner, avoiding high penalties for non-compliance or restoration costs. Artificial intelligence optimizes supply chain management to better predict market demand, control inventory levels, reduce raw material and product waste, and lower operating costs. Meanwhile, an intelligent human resource management system can enhance employee efficiency and optimize human resource allocation, thus reducing labor cost expenditures. In addition, in terms of revenue enhancement, good ESG performance can bring about significant improvement in corporate image and brand value, attracting more consumers and bringing in more sales revenue; by improving customer service experience with AI technology, enterprises can improve customer satisfaction and loyalty and thereby realize stable revenue growth; innovative application of ESG management by enterprise may also give rise to new products or services, therefore creating an additional source of revenue. These impacts feedback on each other and create a virtuous circle: additional capital from cost reduction can continue to be reinvested in ESG innovation, and better ESG performance can bring more revenue and financing advantages, thus helping companies achieve long-term sustainable development.

Based on the above analyses, this study proposes the following hypothesis:

There is no significant relationship between companies' use of artificial intelligence technology and their ESG performance.

4. Research Design

4.1. Sample and Data Sources

This paper investigates the impact of ESG ratings on firms' audit fees using a sample of Chinese A-share listed firms during 2009-2020.The sample selection process is as follows: First, financing companies are excluded because they have significant differences with other companies in terms of their main business, company size, and disclosure. Second, *ST companies are excluded, which have large differences with other companies in terms of their financial indicators and disclosure; third, companies listed in the current year are excluded because they are listed for a shorter period of time, have a shorter survival of historical information and there are large differences in information disclosure; finally, the samples with missing audit fees and control variables are excluded. Ultimately, a total of valid observations is obtained for the period 2007-2022. In order to mitigate the impact of extreme values on the empirical results, this paper uses the winsor2 method to shrink the continuous variables at the 0.01 and 0.99 levels. The ESG ratings data are obtained from the WIND database, while the other data are from the Bloomberg and CSMAR databases.

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4.2. Empirical Model

In order to validate the impact of using AI on firms' ESG performance, the following model was used:

$$ESG_{i,t+1} = \alpha_0 + \beta_1 AI_{i,t} + \gamma X_{i,t} + \delta + \varphi + \varepsilon_{i,,t} \quad (1)$$

The dependent variable ESG uses the ESG ratings provided by the WIND database, which converts ratings from CCC to AAA into quantitative scores ranging from 1-9; the main independent variable AI measures the degree of AI application of a firm by analyzing the text of the firm's annual report and identifying the frequency of the occurrence of AI-related words or sentences; and the control variables include the size of the firm (SIZE, taking the natural logarithm with total assets), gearing ratio (LEV, dividing total liabilities by total assets) and return on assets (ROA, dividing net profit by total assets), while controlling for yearly and firm fixed effects, and lagged one-period values (N+1) are used for all independent and control variables.

Table 1: Variable Definition

Variable Type	**Variable Name**	**Variable Value Description**
Explained Variables	ESG	ESG rating from WIND database, converted from CCC-AAA to scores 1-9
Explanatory Variables	AI	The frequency of AI-related words or sentences in annual reports
Control Variables	LEV	Total liabilities / Total assets
	ROA	Net income / Total assets
	SIZE	Number of board directors
	Cfo	Operating cash flow / Total liabilities
	INDEP	Proportion of independent directors
	Board	Number of board directors
	Firm	Firm fixed effects
	Year	Year fixed effects

5. Empirical Results

Table 2 reports the descriptive statistics of the main variables. In terms of sample distribution, the mean value of ESG score is 6.511, the standard deviation is 1.191, and the median is 6, indicating that the ESG performance of the sample firms is at a moderate level, and the differences between firms are relatively moderate. As for the AI-related text analysis metrics, the mean values of the word frequency (LnWord_MDA1) and the number of sentences (LnSent_MDA1) are respectively 0.429 and 0.412, with standard deviations of 0.84 and 0.8 respectively, and the median of both is 0, indicating that the current disclosure of AI in the annual reports of most companies is still low, but some companies have begun to actively disclose AI-related information.

In terms of control variables, the mean value of firm size (Size) is 22.297, and the standard deviation is 1.267, indicating significant differences in the size of sample firms. The mean value of Return on Assets (ROA) is 0.041, indicating that the average profitability of the sample companies is at a reasonable level. The mean value of gearing ratio (Lev) is 0.448, indicating that the overall debt level of the sample companies is moderate. The mean value of board independence (Indep) is 0.376, which is close to the minimum standard of one-third of the regulatory requirements. Overall, the descriptive statistics of each control variable are within a reasonable range and the sample distribution is relatively balanced.

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Table 2: Summary Statistics

Variable	N	Mean	SD	p25	p50	p75
ESG_N	**20362**	**6.511**	**1.191**	**6**	**6**	**7**
LnWord_MDA1	**20362**	**0.429**	**0.84**	**0**	**0**	**0.693**
LnSent_MDA1	**20362**	**0.412**	**0.8**	**0**	**0**	**0.693**
Lev	20362	0.448	0.202	0.29	0.446	0.601
ROA	20362	0.041	0.071	0.015	0.04	0.072
Size	20362	22.297	1.267	21.41	22.13	23.01
Cfo	20362	0.048	0.07	0.009	0.046	0.088
Indep	20362	0.376	0.063	0.333	0.364	0.429
Board	20362	2.213	0.237	2.079	2.197	2.398

Tables 3 and 4 report the results of the baseline results and robustness tests for this paper. These two tables employ a similar model setup and use different AI text analysis metrics (word frequency and number of sentences) to validate the impact of AI applications on firms' ESG performance, respectively.

Table 3: Baseline Results

	(1)	(2)
	ESG	ESG
LnWord_MDA1	0.054***	0.039**
	(3.27)	(2.46)
Size		0.159***
		(6.52)
ROA		2.019***
		(12.47)
Lev		-0.494***
		(-5.10)
Cfo		0.002
		(0.02)
Indep		-0.024
		(-0.16)
Board		-0.075*
		(-1.79)
Constant	6.488***	3.268***
	(923.07)	(6.11)
Firm FE	YES	YES
Year FE	YES	YES
N	20362	20362
R^2	0.617	0.632

In the baseline results (Table 3), model (1) controls only for firm and year fixed effects and shows a coefficient of 0.054 for AI-related word frequency (LnWord_MDA1), which is significantly positive at the 1% level. The coefficient of AI word frequency decreases (0.039) after the addition of firm characteristics control variables in model (2), but is still significantly positive at the 5% level,

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indicating that there is a robust and positive correlation between a firm's degree of AI application and its ESG performance.

In terms of control variables, the coefficients of firm size (Size) and return on assets (ROA) are significantly positive at 0.159 and 2.019, respectively, indicating that larger and more profitable firms tend to have better ESG performance. While the coefficient of gearing ratio (Lev) is significantly negative (-0.494), indicating that high debt may limit firms' investment in ESG. Board size (Board) is significantly negative at the 10% level, while the effects of board independence (Indep) and operating cash flow (Cfo) are not significant.

Table 4: Robustness Tests

	(1) ESG_N	(2) ESG_N
LnSent_MDA1	0.055***	0.039**
	(3.20)	(2.38)
Size		0.159***
		(6.53)
ROA		2.019***
		(12.47)
Lev		-0.494***
		(-5.10)
Cfo		0.002
		(0.02)
Indep		-0.024
		(-0.17)
Board		-0.075*
		(-1.79)
_cons	6.488***	3.266***
	(915.91)	(6.11)
Firm FE	YES	YES
Year FE	YES	YES
N	20362	20362
r2_a	0.617	0.632

Robustness tests (Table 4) using the number of AI-related sentences (LnSent_MDA1) as a proxy yield highly consistent results with the benchmark regression. Both the significance and economic implications of the coefficients remain robust, further supporting the findings of this paper. The adjusted R-square of both models is around 0.62, indicating a good explanatory strength of the models.

6. Conclusion

This paper uses textual analysis, based on data from Chinese A-share listed companies from 2009 to 2020, to explore the influence of corporate AI application on ESG performance. The results showed that the extent of disclosure of AI-related information in corporate annual reports was significantly and positively related to their ESG rating scores, a relationship robust even when firm size, financial performance, and other characteristic variables were controlled. This paper uses two different text analysis metrics, the frequency of AI-related words and sentence count, to test for robustness. The results are consistent. These findings provide evidence that applying AI technology can enhance the ESG performance of enterprises effectively, hence providing important empirical evidence as to how

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an enterprise can improve its sustainability through digital transformation. Future studies can further investigate the specific mechanisms through which AI application affects ESG performance and the differential performance in different industries and institutional contexts.

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