

ESG Ratings and Corporate Total Factor Productivity: A Perspective on Technological Innovation and Efficiency Improvement

Xingyi Liu

*University of International Relations, Beijing, China
15807017461@163.com*

Abstract: In recent years, with the increasing public attention to environmental and sustainable development issues, green development has become a key driver of high-quality economic growth. Based on data from China's Shanghai and Shenzhen A-share listed companies from 2011 to 2019, this study employs a two-way fixed effects model to empirically investigate the impact of Environmental, Social, and Governance (ESG) ratings on firms' total factor productivity (TFP). The results show that ESG ratings significantly promote TFP, and the conclusion holds after multiple robustness tests. Mechanism analysis reveals that ESG ratings promote TFP through firms' technological innovation and improve efficiency. Further analysis shows that two control zones and perception of economic policy uncertainty have significant positive impacts on ESG ratings. However, the presence of dual-role positions in corporate governance structures inhibits the effect of ESG ratings. This study provides policy recommendations for the environmental external supervision system to promote high-quality corporate development.

Keywords: ESG ratings, total factor productivity, information transmission, soft regulation

1. Introduction

The report of the 20th National Congress of the Communist Party of China emphasizes that high-quality development is the primary task in building a modern socialist country. Achieving high-quality development not only requires sustainable economic growth but also emphasizes economic advancement based on green and coordinated development. One of the key pathways to achieving this is enhancing independent innovation capabilities and improving corporate technological levels [1].

Total factor productivity (TFP) is a core indicator for measuring technological progress and economic efficiency. It reflects the comprehensive contribution of technological advancement, resource allocation optimization, and management efficiency improvement to output under given inputs of traditional production factors such as capital and labor. The study of TFP encompasses micro-level enterprises, meso-level industries, and macroeconomic entities, serving as the engine for long-term economic growth and the foundation for high-quality development. As key microeconomic entities, enterprises must seize the opportunities of the era, accelerate innovation, and successfully achieve digital transformation in the context of the current innovation-driven strategy. This transformation is crucial for improving the quality of economic development [2].

Enterprises have intrinsic motivations to enhance TFP. On one hand, internally, they seek to increase survival probability and risk resistance [3], improve management efficiency and quality [4], and promote the integration of industrial technologies and digital transformation [5]. Enhancing TFP is essential for enterprises' sustainable development. On the other hand, improving TFP aligns with macroeconomic policies that guide enterprises. For example, industrial policies influence TFP through capital allocation efficiency mechanisms [6], and government subsidies can mitigate the negative impact of financial constraints on productivity [7]. Most existing studies link TFP to either enterprises' internal development motivations or macroeconomic policy constraints, with few examining it in the context of external pressures from corporate information disclosure. Therefore, this study empirically investigates the impact mechanism of corporate information disclosure on TFP from the enterprise perspective.

The concept of Environmental, Social, and Governance (ESG) originated from the Socially Responsible Investment (SRI) movement in the late 20th century. With the United Nations' promotion of responsible investment initiatives (PRI) and Sustainable Development Goals (SDGs), ESG disclosure frameworks have been widely adopted by various countries, becoming an essential part of corporate non-financial information disclosure. ESG evaluation covers listed companies, financial institutions, and supply chain enterprises, with professional institutions assessing long-term value creation and risk resilience based on internal rating standards. The 2024 National People's Congress Government Work Report introduced terms such as "green and low-carbon economy," "biodiversity protection," and "new quality productive forces," all of which are closely related to ESG. This highlights ESG's crucial role in the green development aspect of China's high-quality economic development process. ESG ratings have now become an important indicator for evaluating corporate sustainability in China.

Given this context, this study selects financial, operational, and ESG rating data of A-share listed companies from 2010 to 2019. ESG ratings are used to measure corporate non-financial information disclosure. Using a two-way fixed-effects model (year-industry), the study examines whether the external supervision and evaluation pressure from ESG ratings influences corporate TFP, exploring the mechanism through the mediating and moderating effects of technological innovation and efficiency improvement. The findings reveal that ESG ratings significantly enhance corporate TFP.

Compared to previous studies, the possible marginal contributions of this research include: First, while most existing studies link TFP to either enterprises' internal growth drivers or macroeconomic policy constraints, few have examined it within the framework of external pressures from corporate information disclosure. This study empirically investigates the impact of ESG ratings on TFP from a microenterprise perspective. Second, this study explores the mediating effect of ESG ratings on TFP improvement, making an incremental contribution to related research. It reveals the mechanisms through which ESG ratings enhance TFP, specifically by promoting corporate technological innovation and efficiency improvements, providing empirical evidence. Third, the study conducts a moderating analysis from multiple perspectives, including whether enterprises have a dual leadership structure, their perceived economic policy uncertainty, and whether they operate in key regulated zones. This approach integrates macro and micro perspectives, providing insights into policy innovation and valuable policy recommendations for fostering a fair, open, and transparent market environment in China.

The remainder of this paper is structured as follows. Section 2 introduces the theoretical framework and research hypotheses. Section 3 describes the research design and data sources. Section 4 empirically examines whether ESG ratings affect TFP, performs robustness checks, and analyzes the mediating effect from the perspectives of corporate technological innovation and efficiency improvement. It further explores the moderating effects from the perspectives of

micro-level corporate governance and macroeconomic policy. The final section presents research conclusions and policy implications.

2. Theoretical analysis and research hypotheses

2.1. ESG ratings and corporate TFP

Non-financial data is characterized by the absence of mandatory disclosure requirements, broad coverage, and low transparency. These characteristics often lead investors to overlook corporate non-financial information, resulting in misguided decisions. Market participants differ significantly in their market positions, access to information, and ability to process information. According to information asymmetry theory, differences in information processing capabilities among market participants lead to asymmetries, reducing market efficiency.

Research has shown that disclosing non-financial information helps reduce information asymmetry in capital markets and can be used to identify and prevent financial fraud risks to some extent [8]. ESG ratings serve as an effective means to bridge the information gap between investors and enterprises. Under rating pressures, enterprises disclose information about their environmental protection efforts, social responsibilities, and governance effectiveness to stakeholders, enabling investors to gain a more accurate and comprehensive understanding of corporate activities. Firms with higher ratings can enhance investor trust, leading to increased investment willingness, adjustments in corporate capital structures, and improvements in capital allocation efficiency, ultimately enhancing total factor productivity [9].

Furthermore, ESG ratings act as an external supervisory mechanism, reflecting heightened public expectations and demands regarding corporate environmental performance, social responsibility, and governance capabilities. To meet these standards, firms must enhance operational capital, compelling them to undergo digital transformation and technological innovation, which in turn fosters improvements in TFP.

Thus, we propose Hypothesis 1 (H1):

ESG ratings significantly promote corporate total factor productivity.

2.2. ESG ratings, technological innovation, efficiency improvement and corporate TFP

From classical to neoclassical to endogenous growth theories, technological progress has been identified as a key driver of economic growth. Through technological innovation, firms can build sustainable competitive advantages and adapt to changing market conditions [10]. ESG ratings influence both external resource allocation and internal governance effectiveness, facilitating technological advancement. On one hand, ESG ratings attract human capital. Under external ESG rating supervision, firms engage in ESG initiatives, earning social recognition and expanding their influence, which in turn helps attract high-quality talent [11]. The accumulation of human capital and knowledge creation subsequently drive technological innovation. On the other hand, ESG ratings mitigate managerial short-termism. ESG ratings require management to focus on long-term environmental and social value, reducing the likelihood of irrational, high-risk investments aimed at short-term performance gains [12]. Instead, firms are encouraged to make strategic investments in innovation, fostering technological progress. Technological innovation positively impacts both environmental improvement and green total factor productivity [13]. The influence of technology on green TFP has been confirmed by scholars such as Qian Juan & Li JinYE and Liu et al.[14,15], ultimately driving overall TFP growth.

Syverson [16] found that over 50% of differences in corporate TFP can be attributed to internal efficiency factors such as management efficiency and quality control. This highlights efficiency as a core driver of corporate TFP. ESG ratings contribute to improvements in investment and turnover

efficiency. As a crucial link between firms and the market, ESG ratings function as a form of soft regulation. They encourage standardized disclosure, reduce information asymmetry between firms and external investors, and enable more rational investment decisions. By adhering to ESG disclosure frameworks, firms enhance information transmission efficiency and corporate governance, which influences business credit financing [17]. ESG ratings help alleviate both overinvestment and underinvestment issues, thereby improving corporate investment efficiency [18]. Regarding turnover and operational efficiency, ESG ratings also play a positive role. According to stakeholder theory [19], ESG ratings encourage firms to strengthen relationships with stakeholders, build trust with suppliers, employees, and customers, and optimize supply chain response times and business cycles, thereby improving inventory turnover efficiency. Additionally, ESG-driven improvements in employee satisfaction reduce turnover rates and human resource replacement costs, ultimately enhancing corporate operational efficiency.

Thus, we propose Hypothesis 2 (H2) and Hypothesis 3 (H3):

ESG ratings promote corporate total factor productivity through technological innovation.

ESG ratings promote corporate total factor productivity through efficiency improvement.

3. Research design and data sources

This study selects data from A-share listed companies in the Shanghai and Shenzhen stock exchanges from 2011 to 2019 as the research sample. Data sources include the Huazheng (China Securities) website, the CSMAR database, the World Bank, the China City Statistical Yearbook, and reports published by local statistical bureaus. The data is processed as follows: First, filtering and removing missing data. Second, excluding firms established after the sample period and those with negative output values. Third, eliminating samples with discontinuous time-series data. The final dataset includes 5,625 listed companies, comprising 21,286 valid observations.

Based on the theoretical analysis above, this study posits a linear relationship between ESG ratings and corporate TFP. This study employs a panel fixed-effects model as the primary estimation method and constructs the following two-way fixed-effects model (year-industry) as equation (1):

$$TFP_LP_{i,t} = \alpha_0 + \alpha_1 ESG_Score_mean_{i,t} + \sum \alpha Contr + \sum Year + \sum Ind + \varepsilon_{i,t} \quad (1)$$

In equations (1), i represents the firm, and t represents the year. ε denotes the random error term, while $Year$ and Ind represent year and industry fixed effects. Additionally, this study employs firm-level clustered robust standard errors. To eliminate the impact of variable units, variables involved in interaction terms are standardized. TFP_LP represents total factor productivity following the methodology of Lu Xiaodong & Lian Yujun [20], using the Levinsohn-Petrin (LP) method. For robustness checks, the Olley-Pakes (OP) method is also applied. ESG_Score_mean denotes the ESG rating. This study follows Wang Yu [21] and uses the widely applied Huazheng ESG Comprehensive Rating to assess corporate ESG performance. The rating scale ranges from C to AAA, assigned numerical values from 1 to 9, with company-year scores averaged. Control variables include corporate characteristics, governance structure and financial performance, which contain variables below: the corporate maturity indicator (AGE), the shareholding ratio of the largest shareholder ($SHARE$), the proportion of independent directors ($Indep$), the debt-to-asset ratio (LEV), the proportion of fixed assets (PPE), management expenses ($MFee$), leverage ratio (LEV), fixed asset ratio (PPE), and management expenses ($MFee$).

Table 1: Descriptive statistics of variables

variables	observations	mean	median	sd	min	max
TFP_LP	54,650	8.135	8.069	1.150	3.277	13.106
ESG_Score_mean	47,529	4.116	4.000	0.973	1.000	8.000

Table 1: (continued)

<i>lnPat_sum</i>	21,701	83.235	5.000	537.880	0.000	20,983.000
<i>lnInv_sum</i>	21,701	22.635	1.000	194.545	0.000	11,342.000
<i>Inv_Eff</i>	41,761	0.042	0.027	0.054	0.000	1.001
<i>lnAssturnover</i>	655,99	-0.746	-0.657	0.833	-13.816	3.584
<i>firm_uncer</i>	70,944	0.080	0.000	0.271	0.000	1.000
<i>DUAL</i>	33,890	0.357	0.000	0.479	0.000	1.000
<i>Digit</i>	71,196	0.000	0.000	0.000	0.000	0.000
<i>TCZ</i>	70,127	0.151	0.000	0.358	0.000	1.000
<i>AGE</i>	65,729	8.651	7.000	7.631	-17.000	33.000
<i>SHARE</i>	62,095	35.198	32.540	15.801	0.290	100.000
<i>Indep</i>	62,090	0.361	0.357	0.101	0.000	0.800
<i>LEV</i>	56,706	1.629	1.078	18.203	-106.261	2,708.793
<i>PPE</i>	65,656	0.222	0.188	0.170	-0.206	0.971
<i>MFee</i>	61,393	354389850.856	100918337.510	2021670945.768	-355562616.030	90564000000

4. Empirical analysis

4.1. Baseline regression analysis

First, the direct impact of a firm's ESG rating on its TFP is examined by substituting the variables into equation (1) for testing. The regression results are presented in Table 2. Columns (1) and (2) do not include any control variables, with column (2) considering only year and industry fixed effects. Column (3) incorporates all control variables while also controlling for year and industry fixed effects. The results show that the regression coefficients of ESG ratings are significantly positive at the 1% level, indicating that ESG ratings contribute to the improvement of firms' total factor productivity. This provides empirical evidence supporting Hypothesis 1. This conclusion remains valid after a series of robustness tests including measurement error interference, regional heterogeneity bias, interference from firm dynamics, and sensitivity analysis.

Table 2: Baseline regression results

	(1) <i>TFP LP</i>	(2) <i>TFP LP</i>	(3) <i>TFP LP</i>
<i>ESG_Score_mean</i>	0.2395*** (0.0147)	0.2359*** (0.0135)	0.1981*** (0.0125)
Constant	7.3138*** (0.0601)	7.3283*** (0.0557)	7.1500*** (0.0896)
Observations	22,922	22,919	20,575
Adjusted R-squared	0.0517	0.2564	0.3815
Controls	No	No	Yes
Industry Fixed Effects	No	Yes	Yes
Year Fixed Effects	No	Yes	Yes

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses represent standard errors, applicable to all subsequent tables.

4.2. Mechanism analysis

(1) Mediation Effect Analysis

After conducting robustness tests to further validate the stability of the baseline regression, this chapter will explore the core pathways through which ESG ratings influence firms' TFP. In the

theoretical analysis, we propose that ESG ratings primarily enhance TFP through technological innovation and efficiency improvement, and we will examine these pathways separately.

In terms of technological innovation, this study draws on the research of scholars such as Duan Junshan and Zhuang Xudong [22], as well as Chen et al. [23], to characterize corporate technological innovation from a dual-dimensional perspective using the natural logarithm of the total number of patent applications ($\ln Pat_sum$) and the number of valid invention patents ($\ln Inv_sum$). Since some sample firms in this study have zero valid invention patents, to avoid the issue of sample reduction after taking the natural logarithm, we add one to the number of patents before applying the logarithmic transformation. The regression results of key variables are all significantly positive, indicating that ESG ratings can enhance total factor productivity by improving corporate technological innovation. This finding suggests that under the regulatory pressure of the ESG framework, companies not only actively fulfill social responsibilities to build a good reputation but also extend their social influence, creating a talent aggregation effect that facilitates the continuous introduction of high-quality talent and the iterative updating of knowledge creation. At the same time, ESG ratings and information disclosure increase corporate compliance and operational costs, which in turn compels firms to optimize resource allocation efficiency through technological innovation to reduce operational costs and enhance production efficiency.

In terms of efficiency improvement, this study categorizes corporate behavior into investment and financing decisions as well as operational management, with investment efficiency and turnover efficiency serving as key indicators for measuring these aspects. Specifically, investment efficiency (Inv_Eff) is measured following the methods of Richardson [24], where an investment model is constructed, and the residual term is extracted as an indicator of investment inefficiency. A higher residual value indicates more severe investment distortion, meaning lower investment efficiency. Capital operation efficiency is measured using the total asset turnover ratio, calculated as $\ln Assturnover = \text{annual sales revenue of the listed company} / \text{average total asset}$. The specific results show that investment efficiency has a significantly negative impact on TFP, while turnover efficiency significantly enhances TFP. This finding suggests that ESG ratings, as a form of external oversight, require management to focus on the long-term environmental and social value, effectively constraining short-termism. This compels management to accurately, fully, and comprehensively disclose corporate performance, reducing information asymmetry between the company and external investors, improving information transmission efficiency and corporate governance. Consequently, ESG ratings help mitigate both overinvestment and underinvestment while enhancing capital utilization efficiency and corporate operational management capabilities, ultimately improving corporate investment efficiency.

Based on the above analysis, this study concludes that the external supervision and standardized disclosure framework of ESG ratings facilitate human capital accumulation and reduce information asymmetry, thereby promoting corporate technological innovation and efficiency improvement, ultimately driving the growth of TFP. This positive effect aligns closely with the theoretical expectations of Hypothesis 2.

(2) Additional Analysis

According to existing research, both corporate behavior and external policy constraints significantly impact TFP. On one hand, an effective corporate governance model can enhance TFP by optimizing resource allocation [25], making the strengthening of internal governance and external risk control key factors in improving overall corporate performance. On the other hand, appropriate environmental regulation policies can drive corporate transformation and upgrading [26], leading to a significant improvement in production efficiency. In light of this, this study adopts a dual perspective, integrating micro-level corporate governance and macro-level regional policies. At the corporate level, the focus is on internal governance structures and external risk perception to represent

corporate behavior, while at the policy level, attention is given to regional environmental regulations. An interaction model is constructed to explore the moderating effect of ESG ratings on TFP and the multi-level transmission pathways through which this influence occurs.

At the micro-level, this study selects whether the chairman and CEO are the same person (*DUAL*) and the firm's perception of economic policy uncertainty (*firm_uncer*) as key moderating variables representing the impact of internal governance structure and external environment on enterprises. Specifically, *DUAL* is a dummy variable that indicates whether chairman and CEO roles are combined. The measurement of *firm_uncer* follows the textual analysis method of Fang et al. [27] and the policy response model of Nie et al. [28], identifying "economic policy uncertainty sentences" and constructing the *firm_uncer* index based on the ratio of economic uncertainty-related words to total words in the text. The index is then centralized to eliminate unit effects. The results show that the interaction coefficient of *DUAL* is significantly negative while that of *firm_uncer* is significantly positive, indicating that *DUAL* significantly inhibits TFP, while *firm_uncer* significantly and positively promote TFP. This suggests that corporate governance structures play a crucial role in the mechanism through which ESG ratings impact TFP. Specifically, on one hand, the agency problem arising from CEO-chairman duality may lead to managerial short-termism, which affects shareholder decision-making and exacerbates conflicts of interest between management and shareholders. This can cause ESG practices and disclosures to become superficial (e.g., "greenwashing"), reducing the quality of ESG rating information, weakening public trust in the company, and ultimately diminishing the positive impact of ESG ratings on TFP. On the other hand, economic policy uncertainty reflects a firm's perceived risks and uncertainties regarding policy fluctuations. Firms with high ESG ratings tend to have stronger risk resilience and policy adaptability, making them more likely to secure government subsidies, investor trust, and other external resources during periods of policy instability. This helps mitigate the negative impact of economic policy fluctuations, thereby enhancing the effect of ESG ratings on improving TFP.

At the macro level, acid rain control zones or sulfur dioxide pollution control zones (TCZ) have been key environmental regulatory policies in recent years and are expected to play a significant moderating role in the relationship between ESG ratings and TFP. This study uses *TCZ* as a moderating variable, assigning a value of 1 if a firm's city falls within these control zones and 0 otherwise. The results indicate that *TCZ* can significantly and positively promote TFP. This suggests that regional policy regulations have a positive facilitating effect on the mechanism through which ESG ratings influence TFP. The underlying reason is that *TCZ* policies function as environmental regulations that compel firms to meet ESG environmental standards. As a result, companies are forced to invest in green technology research and development, upgrading production processes to reduce unit energy consumption. This significantly enhances China's corporate green production efficiency and green R&D investment, thereby driving improvements in total factor productivity.

In summary, both micro-level corporate governance structures and external risk management, as well as macro-level regional environmental regulation policies, play a significant moderating role in the pathway through which ESG ratings enhance TFP. These findings provide empirical support for the validity of Hypothesis 3.

5. Research conclusions and policy recommendations

5.1. Research conclusions

This study conducts an empirical analysis based on data from 5,625 A-share listed companies in Shanghai and Shenzhen from 2011 to 2019. The main research conclusions are as follows:

(1) ESG ratings significantly enhance TFP. This suggests that ESG ratings, as an external supervisory mechanism, function as a form of soft market regulation, helping to curb managerial

short-termism. By encouraging firms to focus on long-term environmental responsibility, social value, and governance efficiency, ESG ratings improve ESG performance, ultimately leading to higher TFP. The conclusions remain robust after a series of robustness tests.

(2) Mediation analysis reveals that under the ESG rating mechanism, firms improve TFP through technological innovation and efficiency improvements, including investment efficiency and turnover efficiency.

(3) Further analysis indicates that the positive relationship between ESG ratings and TFP is more pronounced for firms located in pollution control zones (TCZ) and those with a higher perception of economic policy uncertainty. These firms also demonstrate stronger compliance with ESG requirements. Additionally, corporate governance structure plays a moderating role—CEO-chairman duality negatively affects the relationship between ESG ratings and TFP improvement.

5.2. Policy recommendations

This study examines the impact mechanism of ESG ratings on corporate TFP. Based on theoretical research and empirical findings, the following recommendations are proposed from both government and corporate perspectives.

(1) Efforts should be made to accelerate the establishment of a unified and authoritative ESG rating standard, which would maximize the role of ESG ratings as an external supervisory mechanism and leverage ESG-driven external incentives to guide enterprises toward high-quality development. At the same time, the government should continue to advance environmental regulatory practices, such as the implementation of pollution control zones (TCZ), strengthening ESG supervision and support for enterprises within these areas.

(2) Enterprises should actively promote the ESG rating process by improving the quality of non-financial information disclosure. They should also strengthen green innovation efforts and enhance human capital accumulation to improve investment efficiency. Additionally, companies need to optimize their governance structures to prevent excessive concentration of decision-making power, which could render ESG practices superficial. Moreover, firms should pay close attention to external risk perception and prevention, strengthening risk resilience and policy adaptability.

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Data Availability Statement: The regression results data used in this study are available from the corresponding author upon request.

References

- [1] Wang, Y. M. (2020). *The great transformation of the century, high-quality development, and the construction of a new development pattern*. *Management World*, (12), 1-13.
- [2] Ren, B. P., & Li, P. (2020). *Path selection for driving China's high-quality economic development through the new economy*. *Journal of Shaanxi Normal University (Philosophy and Social Sciences Edition)*, 49(2), 113-124.
- [3] Zhang, T. J., Huang, J. Z., & Gao, X. (2022). *Corporate management capability, total factor productivity, and enterprise exports—Evidence from China's manufacturing micro-enterprises*. *International Trade Issues*, (05), 155-174.
- [4] Li, T., Dong, Y. M., & Wang, Z. Y. (2018). *Management efficiency, quality capability, and corporate total factor productivity—An empirical study based on the "China Enterprise-Labor Matching Survey"*. *Management World*, (07), 86-99.
- [5] Huang, X. H., & Gao, Y. X. (2023). *Integration of digital and industrial technology and corporate total factor productivity—A study based on Chinese enterprise patent information*. *China Industrial Economics*, (11), 118-136.
- [6] Qian, X. S., Kang, J., Tang, Y. L., & Cao, X. P. (2018). *Industrial policy, capital allocation efficiency, and corporate total factor productivity—An empirical study based on China's 2009 industrial revitalization plan*. *China Industrial Economics*, (08), 42-59.

- [7] Ren, S. M., & Lü, Z. (2014). *Financing constraints, government subsidies, and total factor productivity—Empirical evidence from China's equipment manufacturing enterprises*. *Management World*, (11), 10-23.
- [8] Ye, K. T., & Liu, J. Y. (2021). *Non-financial information and the identification of corporate financial fraud*. *Accounting Research*, (9), 35-47.
- [9] Romer, P. M. (1990). *Endogenous technological change*. *Journal of Political Economy*, 98(5), S71-S102.
- [10] Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York, NY: Free Press.
- [11] Edmans, A. (2011). *Does the stock market fully value intangibles? Employee satisfaction and equity prices*. *Journal of Financial Economics*, 101(3), 621-640.
- [12] Zhang, J. W., Hu, D. D., & Zhou, L. (2022). *Can the digital economy mitigate managerial short-term behavior?—Empirical evidence from real earnings management*. *Economic Management*, 44(01), 122-139.
- [13] Su, K., & Zhou, C. (2021). *Human capital, technological innovation, and green total factor productivity—An analysis based on data from cities along the Yangtze River Economic Belt*. *Economic Issues*, (05), 71-79.
- [14] Qian, J., & Li, J. Y. (2018). *Has technological progress effectively promoted energy conservation and CO₂ emissions reduction?* *Studies in Science of Science*, 36(1), 49-59.
- [15] Liu, G., Wang, B., & Zhang, N. (2016). *A coin has two sides: Which one is driving China's green TFP growth?* *Economic Systems*, 40(3), 481-498.
- [16] Syverson, C. (2011). *What determines productivity?* *Journal of Economic Literature*, 49(2), 326-365.
- [17] Wu, X. F., Tang, M. M., & Zhang, J. Y. (2023). *Does corporate ESG performance affect trade credit financing?—From the perspective of information transmission and governance empowerment*. *Journal of Nanjing Audit University*, 20(3), 41-51.
- [18] Chen, Y., Li, X., & Lin, Z. (2021). *ESG performance and corporate investment efficiency: Evidence from China*. *Journal of Business Ethics*, 172(4), 701-720.
- [19] Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston, MA: Pitman.
- [20] Lu, X. D., & Lian, Y. J. (2012). *Estimation of total factor productivity in China's industrial enterprises: 1999–2007*. *Economic Quarterly*, (2), 541-558.
- [21] Wang, Y., Wang, H. Y., & Xue, S. (2022). *Green taxation and corporate ESG performance—A quasi-natural experiment based on the "Environmental Protection Tax Law"*. *Finance and Economics Research*, 48(09), 47-62.
- [22] Duan, J. S., & Zhuang, X. D. (2021). *Financial investment behavior and corporate technological innovation—Motivation analysis and empirical evidence*. *China Industrial Economics*, (01), 155-173.
- [23] Chen, Y. E., Li, C. Y., Tan, H., & Wang, Y. N. (2024). *The impact of corporate ESG performance on resilience*. *Finance and Economics Theory and Practice*, 45(02), 128-135.
- [24] Richardson, S. A. (2006). *Over-investment of free cash flow*. *Review of Accounting Studies*, 11(2-3), 159–189.
- [25] Zhang, Y., & Yin, Y. F. (2023). *Digital transformation, corporate governance models, and corporate total factor productivity*. *Journal of Zhengzhou University (Philosophy and Social Sciences Edition)*, 56(05), 53-58.
- [26] Zhang, D. Y. (2020). *How does environmental policy affect corporate upgrading in China?—A quasi-natural experiment based on the "TCZ" policy*. *Industrial Economics Research*, (05), 73-85.
- [27] Fang, M. Y., Nie, H. H., Ruan, R., et al. (2023). *Corporate digital transformation and economic policy uncertainty perception*. *Financial Research*, (02), 21-39.
- [28] Nie, H. H., Ruan, R., & Shen, J. (2020). *Corporate uncertainty perception, investment decisions, and financial asset allocation*. *World Economy*, 43(06), 77-98.