

How ESG Performance Affects Enterprise Total Factor Productivity: The Moderating Role of Regional and Corporate-Level Innovation Capacity

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Received July 11, 2024; **Revised** August 24, 2024; **Accepted** September 15, 2024

Abstract

ESG (environmental, social, and governance) is critical to high-quality enterprise development, yet its impact on total factor productivity (TFP) and the underlying mechanisms remain underexplored. This study addresses this gap by examining how ESG performance affects TFP, with a specific focus on the moderating effects of innovation capacity at both regional and corporate levels. This study analyzes panel data from Chinese A-share listed companies (2015–2022) using a fixed-effects regression model that accounts for year, industry, and corporate-specific factors. The findings remain robust even when employing alternative measures for key variables and incorporating one- and two-period lags for independent variables. The results demonstrate that while ESG performance significantly boosts TFP, the moderating effects of regional and corporate innovation capacities can paradoxically weaken this positive relationship. Specifically, higher levels of regional and corporate innovation capacities—typically regarded as drivers of competitive advantage—can lead to resource dispersion and priority misalignment, thereby diluting the beneficial effect of ESG initiatives on TFP. This innovative finding underscores the critical importance of strategic resource allocation and a balanced approach to innovation. Even in contexts with limited innovation resources, strong ESG practices substantially enhance TFP. This study underscores the pivotal role of ESG performance in enhancing TFP across diverse innovation environments at both regional and corporate levels. It offers novel theoretical insights and strategic recommendations, advocating for the seamless integration of ESG considerations into innovation strategies by both governments and enterprises. Additionally, investors should critically assess how well enterprises balance their

innovation efforts with ESG initiatives to optimize TFP and foster sustainable, high-quality development.

Keywords: Environmental, Social, and Governance (ESG) performance; total factor productivity; regional innovation capacity; R&D innovation capacity; moderating effect model

Introduction

In today's globalized economy, enterprises face an array of complex challenges, particularly in the realm of sustainable and high-quality development. The growing focus on environmental, social, and governance (ESG) issues underscores their critical role in driving long-term value generation (Dmuchowski et al., 2023; Edmans, 2023). ESG performance has emerged as a key indicator of an organization's sustainability efforts, while total factor productivity (TFP) remains a fundamental measure of enterprise productivity and technological progress, essential for fostering high-quality economic development (Habib et al., 2019; Yu et al., 2020). The strong correlation between TFP and sustainable enterprise development further solidifies its importance, positioning enterprises with higher TFP as leaders in performance and growth (Deng et al., 2023; Ma et al., 2022).

Scholarly inquiries into the impact of ESG performance on enterprise activities increasingly concentrate on innovation levels and productivity metrics (Shen et al., 2023). Previous studies have offered substantial insights into the dynamics of an enterprise's ESG performance and TFP. A burgeoning corpus of academic literature and empirical investigations endorses the notion that ESG performance has a notably positive effect on TFP (Deng et al., 2023; Fu & He, 2023; Ge et al., 2022; Ma et al., 2022; Tan et al., 2024; Xue et al., 2024; Zheng & Talib, 2024). This underlines the premise that enterprises can fulfill social and environmental objectives and boost their productivity and economic outcomes by enhancing their ESG performance.

Recent studies have revealed that the relationship between ESG performance and TFP is shaped by a complex interplay of factors, including ownership structure, industry characteristics, size, location, higher visibility, reputation, audit quality, and CEO overseas experience, all of which significantly influence the trajectory and magnitude of the ESG–TFP relationship (Deng et al., 2023; Ge et al., 2022; Ma et al., 2022; Shen, 2024; Xue et al., 2024). Despite these insights, the effects of ESG performance on TFP, particularly the role of innovation capacities, remain underexplored.

Recent work acknowledges the role of innovation activities at both the regional and corporate levels as pivotal drivers of economic expansion and productivity enhancement (Tu et al., 2023). Regional innovation capacity (RIC) encompasses a region's technological infrastructure, scientific research capabilities, innovation resources, and policy support. While RIC is recognized for significantly promoting green growth and enhancing green TFP (Hu et al., 2019; Lee et al., 2022), its influence is complex. Innovation activities are shaped by the regional innovation ecosystem, with RIC potentially exerting both direct and subtle internal effects on firms' innovation propensities (Daresh et al., 2020; Rodríguez-Gulías et al., 2021). Although high RIC environments may stimulate enterprise innovation, they can also introduce challenges such as resource fragmentation and increased competition, which may dilute the emphasis on ESG-related improvements. This nuanced role of RIC suggests it may act as a subtle and potentially negative moderator in the ESG–TFP relationship, particularly when innovation efforts are dispersed or market conditions shift. Thus, further empirical research is necessary to clarify RIC's effect on this dynamic.

R&D innovation capacity (RDC) encompasses not only an enterprise's ability to develop new products, processes, and technologies but also its capacity to allocate and manage resources in R&D efforts. While R&D investment is vital for promoting TFP and ensuring long-term growth (Ding et al., 2024), its interaction with ESG initiatives often yields complex outcomes. The pursuit of RDC and ESG objectives may involve resource competition, conflicting goals, or divergent strategic focuses, which can profoundly affect TFP. When corporate resources are constrained, excessive allocation to ESG initiatives might divert resources from green innovation (Yuan & Cao, 2022), and fulfilling ESG responsibilities may inadvertently hinder green innovation within industrial enterprises (Zhu et al., 2023).

The relationship between ESG performance and TFP has emerged as a key area of scholarly focus, particularly regarding the moderating roles of innovation capacities at both regional and corporate levels. While previous research often highlights the positive effect of R&D intensity on the ESG–corporate performance nexus (Baek & Lee, 2024; Hassan & Naveed, 2024), contrasting evidence suggests that ESG benefits may be limited under certain conditions, with innovation activities potentially serving as a negative moderator (Shen et al., 2022). Duan et al. (2023) further emphasize the risks of uncertain R&D investments, which can strain financial resources and disrupt business operations, thereby negatively moderating the ESG–corporate value relationship. These insights underscore the imperative for companies to strategically balance investments in ESG initiatives with R&D efforts.

Despite extensive research on ESG and its impact on TFP, a critical gap remains in understanding how regional and corporate-level innovation capacities influence this relationship. It is still uncertain whether these capacities amplify or mitigate ESG's effects on TFP. This study aims to fill this gap by conducting empirical analysis, introducing a novel theoretical framework, and providing practical insights. The findings are designed to help companies and policymakers better align sustainable development goals with innovation strategies, thereby contributing to the ongoing discourse on ESG, innovation, and TFP.

Objective of study

1. To examine the effect of ESG performance on enterprise TFP.
2. To explore the moderating effect of regional innovation capacity on the ESG performance–TFP relationship.
3. To investigate the moderating effect of R&D innovation capacity on the ESG performance–TFP relationship.

Literature Review

ESG performance and TFP

ESG evaluates an enterprise's performance in terms of environmental protection, social responsibility, and internal governance, whereas TFP measures the efficiency of an enterprise's output after considering all inputs (e.g., labor and capital). According to the resource-based view (RBV), a corporation is a repository of both tangible and intangible resources, which are key to achieving competitive advantage and higher returns (El Shafeey & Trott, 2014). Within this theoretical context, superior ESG performance acts as a unique resource that can elevate firm efficiency, encourage innovation, and increase employee productivity, thereby contributing to enhanced TFP (Huang & Yu, 2024). Stakeholder theory underscores the criticality of nurturing robust relationships with all stakeholders, including employees, customers, suppliers, communities, and governments, for a firm's success (Parmar et al., 2010). Optimal ESG performance is instrumental in establishing and sustaining these relationships, thereby bolstering operational efficiency and market positioning, which ultimately reflects in enhanced TFP (Deng et al., 2023). Signaling theory elucidates how firms convey their attributes to the market through their actions (Spence, 2002). The disclosure of corporate ESG initiatives acts as a signaling mechanism (Hu et al., 2023). Superior ESG performance

functions as a positive indicator of proficient risk management and long-term growth prospects. This in turn attracts more investors and high-caliber employees, thereby indirectly facilitating an increase in TFP (Yu et al., 2024).

ESG performance is increasingly identified as essential for long-term sustainable development and competitive advantage (Zumente & Bistrova, 2021). ESG performance ratings are an important measure of nonfinancial performance and affect TFP (Deng et al., 2023). The existing literature generally supports the opinion that ESG performance has a positive effect on enhancing TFP (Deng et al., 2023; Fu & He, 2023; Ma et al., 2022; Tan et al., 2024). In a detailed examination of this relationship, Deng et al. (2023) observed a statistically significant effect in which an increment of one unit in an enterprise's ESG rating was associated with a 1.19 percent increase in TFP. Yu and Chen (2024) demonstrate that ESG advantages significantly boost TFP, indicating that enterprises are motivated to pursue ESG practices for the associated productivity benefits.

ESG performance is a strategic resource that can increase TFP through mechanisms, such as optimizing resource allocation, enhancing corporate reputation, reducing costs, and attracting talent. First, enterprises with superior ESG performance pay more attention to ESG issues, thereby increasing resource use efficiency, minimizing waste (Xie et al., 2019), and increasing TFP. Second, these entities tend to receive more investment and cooperation (Xiao et al., 2022), facilitating resource allocation and technological progress, which, in turn, increases TFP (Velte, 2017). Third, improved ESG performance may also generate beneficial externalities such as improved corporate reputation, enhanced consumer trust and loyalty, and increased market demand and product pricing (Waheed & Zhang, 2022), which can contribute to increased productivity and TFP. In addition, enterprises with high ESG performance tend to adhere to their social responsibilities, potentially increasing employee morale and productivity (Tunio et al., 2021). Thus, the hypothesis is as follows:

H1: ESG performance has a positive effect on TFP.

The moderating effect of RIC

Subject to constraints such as natural endowments, geographical positioning, and socioeconomic conditions, spatial disparities in regional innovation capacity in China remain pronounced, imposing significant limitations on the nation's economic transition and high-quality development (Yang & Chen, 2023). This situation requires a coordinated approach involving both technical and institutional strategies to mitigate regional resource and environmental challenges (Hu et al., 2019). As an external environmental factor, regional innovation capacity (RIC) subtly influences the internal drivers of corporate innovation and high-quality development (Rodríguez-Gulías et al.,

2021). Consequently, variations in regional innovation capabilities may moderate the effect of ESG performance on TFP.

First, while a high level of RIC enhances enterprise innovation by providing a conducive environment, knowledge spillovers, and policy support, this study posits a more nuanced view. Despite RIC's traditional role as an innovation catalyst, in regions with strong innovation capabilities, the positive effect of ESG on TFP may be diluted due to resource reallocation, intensified competition, and shifting priorities, potentially leading to a negative moderating effect. Second, drawing on resource dependence theory and innovation ecosystem theory, innovation is pivotal in shaping firms' reliance on key resources and managing uncertainty (Adner & Kapoor, 2010; Hillman et al., 2009). In highly innovative regions, corporations may prioritize innovation over ESG initiatives. This prioritization can result in a "resource shift effect," where resources and attention are diverted away from sustainable practices, weakening the effect of ESG on TFP as innovation efforts overshadow ESG activities. Third, Schumpeter's innovation theory posits that innovation lies at the heart of economic transformation (Dabic et al., 2011), often unleashing a "storm of creative destruction." In regions characterized by robust innovation capacities, corporations may prioritize immediate innovation gains over long-term ESG investments, potentially diminishing the effectiveness of ESG initiatives in enhancing TFP. This theoretical framework suggests that in regions with high innovation capacity, the positive effect of ESG performance on TFP may be attenuated. Fourth, imbalances in regional innovation capacities lead to conflicting short- and long-term objectives and uncertainty in innovation efforts. A regional emphasis on enhancing innovation capacity might skew resources toward innovation activities, impairing ESG performance, particularly under resource constraints. Although increasing RIC could positively impact TFP in the long term, it might have detrimental short-term effects by diverting resources from ESG initiatives, negatively impacting both ESG performance and TFP. Finally, in regions with high RIC, the complexity and competitiveness of advanced innovation ecosystems might divert resources toward disruptive innovations at the expense of ESG efforts. The pressure to meet diverse stakeholder demands and intense market expectations for innovation outputs could weaken the synergy between innovation and ESG goals, ultimately contributing to a negative moderating effect of RIC on the ESG–TFP relationship. Collectively, these perspectives highlight the potential for RIC to negatively moderate the ESG–TFP relationship, particularly when innovation resources are fragmented or when market dynamics shift focus away from incremental ESG improvements. Thus, the hypothesis is as follows:

H2: Regional innovation capacity negatively moderates the effect of ESG performance on TFP.

Moderating effect of R&D innovation capacity

Based on the perspectives of high- and low-quality innovation, Huang et al. (2022) find that innovation overall inhibits the improvement of enterprise TFP. Duan et al. (2023) underscores the need for enterprises to navigate the intricate balance between ESG performance and R&D investment, highlighting that finite capital resources constrain the zero-sum dynamic wherein investment allocation between these two domains. This delicate balance accentuates the reciprocal encroachment of resources between ESG and R&D investments, suggesting that an intensification in R&D innovation capacity potentially detracts from ESG performance, and consequently, TFP.

First, Yin et al. (2021) emphasized that efficient resource allocation is crucial for the high-quality development of enterprises, with varying resource combinations significantly impacting operational efficiency. Building on resource allocation theory, this study advocates for strategically prioritizing the efficient allocation of scarce economic resources. This strategy requires judicious allocation between R&D innovation and ESG activities. A disproportionate emphasis on the former risks undermining ESG initiatives and diminishing ESG performance. Over time, this neglect can erode a firm's social standing, environmental stewardship, and governance quality, adversely affecting its TFP. Second, the drive for competitive advantage often propels firms to prioritize technological innovation and product development at the expense of ESG commitments. This shift can escalate operational risks, diminish employee and customer satisfaction, and strain relations with government and community stakeholders, culminating in detrimental effects on TFP. Third, the overzealous pursuit of innovation can expose enterprises to excessive technological and market risks while decreasing management and investment in ESG. High-risk innovation endeavors may escalate cost pressure, potentially leading to resource wastage and unsuccessful investment, thus impairing enterprise productivity. Collectively, enterprises with strong innovation capacities may see reduced benefits from ESG investments due to resource reallocation, strategic priorities, and industry dynamics. Thus, the hypothesis is as follows:

H3: R&D innovation capacity negatively moderates the effect of ESG performance on TFP.

Conceptual Framework

Figure 1 outlines the conceptual framework of the study. The framework diagram illustrates the relationships between four key variables: ESG Performance (ESG), Total Factor Productivity (TFP), Regional innovation capacity (RIC), and R&D innovation capacity (RDC). This framework posits that, while ESG positively affects TFP, both RIC and RDC negatively moderate this relationship. High levels of RIC may divert companies' resources and focus away from ESG initiatives, thereby diminishing ESG's positive effect of ESG on TFP. Similarly, RDC may lead companies to prioritize technological and product innovation over ESG activities, further suppressing the beneficial effect of ESG on TFP.

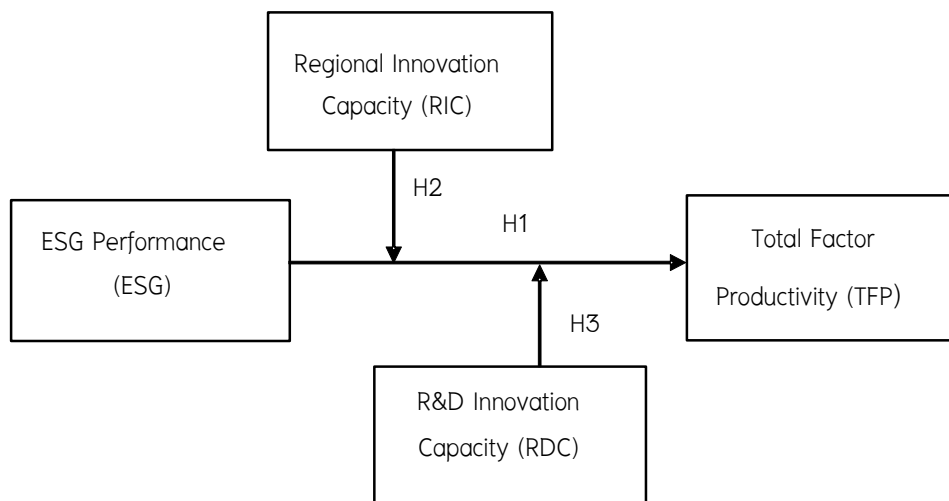


Figure 1 Conceptual framework

Research Methodology

This study investigates the influence of ESG performance on TFP among publicly listed Chinese companies, utilizing secondary data from established databases. Employing a multivariate linear regression model with fixed effects, implemented in STATA 18.0, the study rigorously controls for unobserved heterogeneity. This methodological approach allows for a precise examination of the relationships between ESG performance, regional innovation capacity (RIC), and R&D innovation capacity (RDC).

1. Sample selection and data sources

This study focuses on A-share listed companies that received ESG ratings from Huazheng, China, between 2015 and 2022. The ratings served as a quantitative assessment of ESG

performance. Secondary data was used in this research, following the sample selection process as outlined below. First, companies in the financial and insurance sectors, ST and ST* companies, and observations with missing data were removed because of their industry specifics, poor operating conditions, and potential data outliers. Furthermore, to mitigate the impact of extreme values, data at the 1% and 99% percentiles were winsorized. The primary data sources are the China Stock Market and Accounting Research (CSMAR) and WIND databases (Guo Tai An (CSMAR), 2023; Wind, 2023), while the regional innovation capacity data were sourced from the China Regional Innovation Capacity Evaluation Report (China Science and Technology Development Strategy Research Group & Chinese Academy of Sciences University China Innovation and Entrepreneurship Management Research Center, 2015–2022). The final sample comprises 22,708 annual observations.

2. Dependent variable: TFP

Currently, the main methods used to measure firms' TFP are Ordinary Least Squares (OLS), Generalized Method of Moments (GMM), Fixed Effects (FE), Olley and Pakes (OP), and Levinsohn and Petrin (LP). Building on the approaches adopted in prior research, such as Deng et al. (2023), this study applies the LP (Levinsohn & Petrin, 2003) method to measure TFP as a proxy variable. In the robustness test, this study applies the OP (Olley & Pakes, 1996) method to estimate TFP.

3. Independent variable: ESG performance

The primary sources of ESG rating data in academic research are Huazheng (29%), Bloomberg (24%), and SynTao Green Finance (12%) (Shen et al. 2023). Similar to Ma et al. (2022), this study employs China Huazheng ESG rating data to evaluate enterprise ESG performance. The ESG ratings generated through the assignment method encompass nine levels, from C to AAA, which are assigned numerical values from 1 to 9, where 1 indicates a C rating and 9 indicates an AAA rating. The proxy variables for ESG performance are derived from quarterly means. In addition, year-end ESG rating data were used in the robustness test.

4. Moderator variable: regional innovation capacity (RIC) and R&D innovation capacity (RDC)

This study uses findings from the China Regional Innovation Capacity Evaluation Report as a proxy for RIC (China Science and Technology Development Strategy Research Group & Chinese Academy of Sciences University China Innovation and Entrepreneurship Management Research Center, 2015–2022). Published annually for 23 consecutive years, the Evaluation Report on China's RIC is part of the National Innovation Survey System and is considered an authoritative assessment of regional development in China. The report employed a four-level indicator system to

comprehensively evaluate China's RIC, including factors such as knowledge creation, knowledge acquisition, enterprise technological innovation, innovation environment, and economic performance. This provides insight into regional performance in areas such as enterprise innovation, basic research, original innovation, and innovation systems. Following Chen and Shan (2022), this study utilizes the comprehensive utility value derived from the Evaluation Report of China's Regional Innovation Capacity as a proxy variable for RIC.

In this study, R&D innovation investment, measured by total R&D expenditure, serves as a proxy for R&D innovation capacity, reflecting an enterprise's commitment to innovation. To ensure data stability, the R&D investment data were logarithmically transformed (Di Simone et al., 2022; Rahman & Howlader, 2022).

5. Control variables

The empirical model in this study, drawing on Ge et al. (2022) and Fu & He (2023), incorporates several control variables: enterprise size (Size), age (Age), growth (Growth), asset-liability ratio (Lev), operating cash flow (CFO), and institutional investor shareholding (INST). In addition, the analysis controls for year, industry, and individual fixed effects. Table 1 summarizes the definitions of these variables.

Table 1. Variable Definitions.

Type	Variable	Symbol	Definitions	Source of Data
Dependent variable	Total Factor Productivity	TFP	The TFP of enterprises calculated with the Levinsohn–Petrin (LP) method	The index constructed by James Levinsohn et al.
Independent variable	ESG performance	ESG	Based on the Huazheng ESG rating from AAA to C, that is 9 to 1, respectively. Measured using quarterly averages.	WIND database
Moderator variable	Regional innovation capacity	RIC	Overall utility value score of regional innovation capability	China Regional Innovation Capacity Evaluation Report
	R&D innovation capacity	RDC	Natural logarithm of Corporate R&D innovation investment plus 1	CSMAR database
Control variables	Enterprise size	Size	Natural logarithm of total assets	CSMAR database
	Enterprise age	Age	Ln (Current year – Year of establishment of the enterprise + 1)	
	Enterprise growth	Growth	Main operating income growth rate	
	Asset–liability ratio	Lev	Total liabilities / Total assets	
	Operating cash flow	CFO	Net cash flows from operating activities / Total assets	
	Institutional investor shareholding	INST	Total number of shares held by institutional investors / Total number of shares	

6. Model specification

Model (1) tests the effect of ESG performance on TFP.

$$TFP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_j \sum_j Controls_{i,t} + \sum Year + \sum Industry + \sum Id + \varepsilon_{i,t} \quad (1)$$

Model (2) tests whether the RIC moderates the effect of ESG performance on TFP.

$$TFP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 RIC_{i,t} + \beta_3 ESG_{i,t} \times RIC_{i,t} + \beta_j \sum_j Controls_{i,t} + \sum Year + \sum Industry + \sum Id + \varepsilon_{i,t} \quad (2)$$

Model (3) tests whether R&D innovation capacity moderates the effect of ESG performance on TFP.

$$TFP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 RDC_{i,t} + \beta_3 ESG_{i,t} \times RDC_{i,t} + \beta_j \sum_j Controls_{i,t} + \sum Year + \sum Industry + \sum Id + \varepsilon_{i,t} \quad (3)$$

In the model, $TFP_{i,t}$ denotes total factor productivity, $ESG_{i,t}$ represents ESG performance, $Controls_t$ includes control variables, $RIC_{i,t}$ signifies regional innovation capacity and $RDC_{i,t}$ indicates R&D innovation capacity. Where, i and t represent enterprises and years, respectively; β denotes the assumed parameter; Year, Industry, and Id represent the year, industry, and individual fixed effects, respectively; and ϵ represents the error term. To mitigate multicollinearity, the interaction terms were mean-centered. The regression models and data processing in this study were conducted using Stata 18.

Results

1. Descriptive and correlation analysis

Table 2 presents the descriptive statistics of the variables. The sample companies exhibited a range of TFP values, with a maximum of 11.22, a minimum of 6.252, and an average of 8.398, highlighting the variations among the Chinese A-share listed companies. The mean ESG rating was 4.164, with a variance of 1.062 and a median of 4.250, suggesting an average ESG performance rating ranging from B to BBB. The ESG performance across listed companies is diverse. RIC has an average value of 41.08, with significant disparities between the maximum and minimum values, indicating a substantial variation in innovation capacities among different regions. The average value of R&D innovation capacity is 16.30, with a standard deviation of 5.672, indicating significant variability in R&D innovation capacity among listed companies. These data underscore the substantial differences in TFP, ESG performance, RIC, and R&D innovation capacity among listed Chinese companies, emphasizing their varying degrees of influence. The statistics for the other variables align closely with those of the existing studies. A multicollinearity test was conducted, and the results are listed in Table 2. The values for each variable were less than 10, and the mean VIF was 1.23. The results indicated the absence of significant multicollinearity among the variables.

Table 2. Descriptive statistics of the main variables

Variable	N	Mean	SD	Min	Median	Max	VIF
TFP	22708	8.398	1.047	6.252	8.289	11.22	–
ESG	22708	4.161	1.062	1.250	4.250	6.250	1.12
RIC	22708	41.08	13.81	18.17	42.82	65.49	1.03
RDC	22708	16.30	5.672	0.000	17.95	22.08	1.08
Size	22708	22.38	1.301	20.07	22.18	26.43	1.85
Age	22708	2.999	0.287	2.079	3.045	3.611	1.07
Growth	22708	0.160	0.389	–0.568	0.100	2.272	1.01
Lev	22708	0.421	0.198	0.063	0.413	0.887	1.51
CFO	22708	0.050	0.067	–0.144	0.048	0.249	1.08
INST	22708	43.01	24.87	0.237	44.23	91.80	1.31

Note: Data were analyzed using Stata, including the following tables.

Source: Author's own elaboration.

2. Main regression analysis

Table 3 presents the regression results of the basic model. In Column (1), without adding control variables, but controlling for industry, year, and individual effects, the coefficient of the effect of ESG performance on TFP is 0.0695 ($t=11.2955$, $p<0.01$), indicating a significantly positive effect at the 1% level. Column (2) incorporates the corporate-level control variables. The coefficient for the effect of ESG performance on TFP is 0.0276 ($t=5.7694$, $p<0.01$), still significantly positive at the 1% level. The significance and signs of the regression coefficients for the core explanatory variables remain consistent. In terms of economic significance, enhanced ESG performance leads to an increase of approximately 2.76% in enterprise TFP. Among the control variables, enterprise size (Size), age (Age), growth (Growth), operating cash flow (CFO), and institutional investor shareholdings (INST) have significantly positive coefficients. This finding implies that greater size, longer operations, faster revenue growth, abundant cash flow, and higher institutional shareholding are conducive to TFP improvements, aligning with the theoretical expectations. This result suggests that an ESG advantage effectively contributes to enhancing TFP, thus supporting the validity of Hypothesis 1.

3. Moderating effect test

Table 3 presents the moderating effects of RIC and R&D innovation capacity. In Column (3), the regression coefficient for the effect of ESG performance on TFP is 0.0273 ($t=5.6994$, $p<0.01$), indicating a significantly positive correlation. However, the regression coefficient for the interaction term between ESG performance and RIC with TFP was -0.0007 ($t=-2.1039$, $p<0.05$), demonstrating a significant negative correlation. Figure 2 illustrates the moderating influence of RIC

on ESG performance and TFP. The diagram indicates that an enhancement in ESG performance correlates with an increase in TFP, particularly in contexts characterized by lower levels of RIC. Conversely, at elevated RIC levels, while a positive correlation between ESG performance and TFP persists, the magnitude of this positive effect diminishes. These results indicate that RIC negatively moderates the effect of ESG performance on TFP, thus confirming Hypothesis 2.

Table 3. Baseline and moderating effects analysis.

Variable	(1)	(2)	(3)	(4)
	TFP	TFP	TFP	TFP
ESG	0.0695*** (11.2955)	0.0276*** (5.7694)	0.0273*** (5.6994)	0.0285*** (5.8896)
RIC			-0.0019 (-1.2442)	
ESG×RIC			-0.0007** (-2.1039)	
RDC				0.0017 (1.2169)
ESG×RDC				-0.0038*** (-3.9972)
Size		0.5258*** (32.5200)	0.5269*** (32.5345)	0.5229*** (32.4950)
Age		0.4000*** (3.4253)	0.4042*** (3.4607)	0.4188*** (3.5840)
Growth		0.2548*** (27.7601)	0.2544*** (27.7679)	0.2542*** (27.8414)
Lev		0.0355 (0.6869)	0.0343 (0.6656)	0.0390 (0.7593)
CFO		0.7831*** (13.1382)	0.7817*** (13.1357)	0.7852*** (13.2452)
INST		0.0010** (2.0224)	0.0010** (2.0244)	0.0010** (1.9653)
_cons	7.7019*** (28.6846)	-4.9467*** (-9.3241)	-4.8603*** (-9.1733)	-4.8371*** (-9.2745)
Year Fixed	Yes	Yes	Yes	Yes
Industry Fixed	Yes	Yes	Yes	Yes
Individual Fixed	Yes	Yes	Yes	Yes
N	22708	22708	22708	22708
R ²	0.2317	0.5095	0.5099	0.5114
adj. R ²	0.2292	0.5078	0.5081	0.5097

Notes: The t-statistics are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Source: Author's own elaboration.

Next, this study tests the moderating role of corporate-level R&D innovation capacity. In Column (4), the regression coefficient for the effect of ESG performance on TFP is 0.0285 ($t=5.8896$, $p<0.01$), indicating a significantly positive correlation. However, the regression coefficient for the interaction term of ESG performance and R&D innovation capacity with TFP was -0.0038 ($t=-3.9972$, $p<0.01$), demonstrating a significant negative correlation.

Figure 3 illustrates the moderating influence of RDC on ESG performance and TFP. The analysis reveals that ESG performance universally enhances TFP across varying RDC levels; however, the magnitude of this impact differs. Specifically, RDC significantly negatively moderates the effect of ESG performance on TFP, suggesting that the positive effect of ESG performance on TFP is more pronounced at lower levels of RDC. These observations imply that the beneficial effects of ESG performance on enterprise TFP diminish as RDC increases, thus supporting Hypothesis 3.

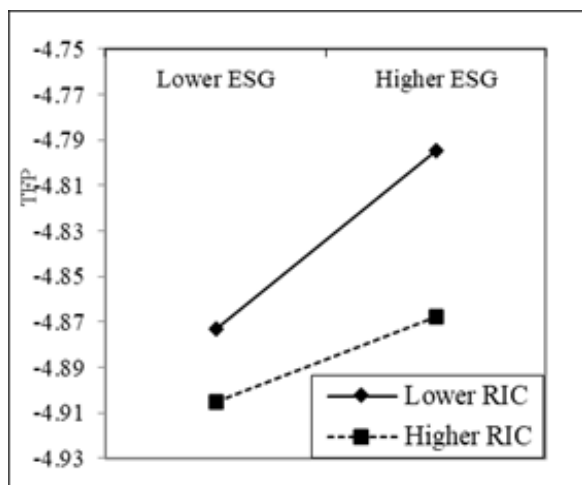


Figure 2. The moderating effect of RIC

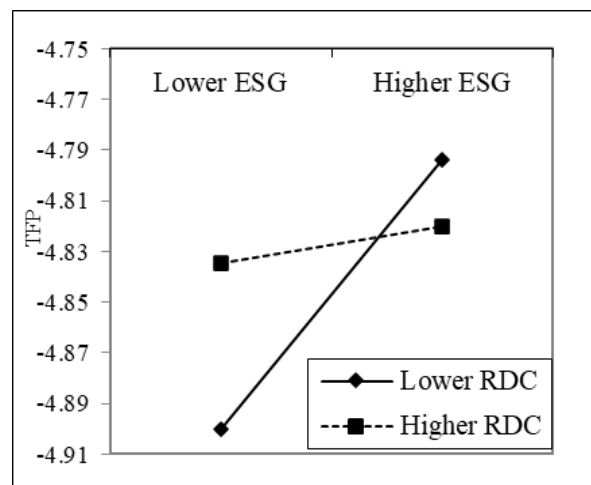


Figure 3. The moderating effect of RDC

4. Robustness Tests

In this study, various robustness checks were conducted to ensure the reliability of the results. First, the Levinsohn–Petrin (LP) method was used as the primary approach to measure TFP, with the Olley–Pakes (OP) method employed as an alternative to test the robustness of the baseline model; the results, as shown in Column (1) of Table 4, confirm the significantly positive effect of ESG performance on TFP. Second, to validate the findings further, the end-of-year Huazheng ESG ratings were used as an alternative measure of ESG performance, and the results in Column (2) of Table 4 remain positive and significant at the 1% level. Lastly, to address potential endogeneity issues, the study tested the lagged effects of both independent and dependent variables, with the results in

Columns (3) to (5) of Table 4 consistently showing a significantly positive effect of ESG performance on TFP, confirming the robustness and mitigating concerns of reverse causality.

Table 4. Robustness test regression results.

Variable	(1)	(2)	(3)	(4)	(5)
	TFP_OP	TFP	TFP	TFP	L.TFP
ESG	0.0177*** (3.8807)				0.0260*** (5.4242)
ESG_hz		0.0148*** (4.4433)			
L.ESG			0.0152*** (3.1108)		
L2.ESG				0.0131*** (2.5804)	
Controls	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Individual	Yes	Yes	Yes	Yes	Yes
N	22708	22708	18213	14818	18213
R ²	0.4596	0.5084	0.4893	0.4539	0.5518
adj. R ²	0.4577	0.5067	0.4872	0.4513	0.5500

Notes: The t-statistics are in parentheses. * p< 0.1, ** p< 0.05, *** p< 0.01.

Source: Author's elaboration.

Discussion

Through quantitative research, this study constructed a fixed-effects model and empirically tested the effect of ESG performance on TFP and the moderating effects of regional innovation capacity and corporate R&D innovation capacity. This validation supported the three hypotheses and achieved the three research objectives. The results were analyzed as follows:

1. ESG performance and TFP

Results from Research Objective 1 found that ESG performance has a positive and significant effect on TFP. This was because effective ESG practices optimize resource allocation, strengthen stakeholder relationships, and send positive market signals, all of which contribute to enhancing a company's production efficiency and TFP. The results of this study align with those of previous research by Deng et al. (2023), Ma et al. (2022), and Xue et al. (2024), which similarly observed that strong ESG performance correlates with higher TFP. The consistency across the studies

emphasizes the robustness of the ESG–TFP relationship and underscores the strategic importance of ESG initiatives in promoting sustainable economic growth and increasing TFP. Supported by resource–based, stakeholder, and signaling theories, these findings underscore the necessity of incorporating ESG practices into corporate strategies and policy frameworks to maximize TFP and foster sustainable development. This alignment between empirical evidence and theoretical frameworks provides a compelling rationale for prioritizing ESG factors in corporate decision–making and policy design.

2. Moderating effect of regional innovation capacity

Results from Research Objective 2 found that regional innovation capacity negatively moderates the effect of ESG performance on TFP. This was because the dispersion of resources and heightened competition in regions with high innovation capacities can dilute the focus on ESG initiatives, thereby weakening their impact on TFP. The results of this study align with the resource–based theory, which posits that a company's competitive advantage is derived from its unique resources and capabilities. However, in highly innovative regions, companies may be compelled to allocate resources across multiple areas, such as technological R&D and market expansion, making it challenging to concentrate on ESG–related efforts. Consequently, this dispersion diminishes the potential positive effects of ESG performance on TFP, underscoring the complex interplay between regional innovation dynamics and ESG–driven productivity improvements.

3. Moderating effect of corporate R&D innovation capacity

Results from Research Objective 3 found that corporate R&D innovation capacity negatively moderates the effect of ESG performance on TFP. This was because companies with strong R&D capacities might prioritize short–term innovation outcomes to meet shareholder and market expectations, which can lead to reduced investments in long–term ESG projects. The results of this study align with stakeholder theory, which suggests that companies must balance the interests of various stakeholders. However, the pressure to deliver immediate innovation results often takes precedence, weakening the commitment to ESG initiatives and thus diminishing their positive effect on TFP. Furthermore, the study's findings resonate with those of Huang et al. (2022), who highlighted that a focus on low–quality innovation can inhibit the enhancement of enterprise TFP. In such cases, the misallocation of resources toward short–term gains at the expense of high–quality, sustainable innovation leads to inefficiencies, thereby overshadowing the potential benefits of ESG performance on TFP.

New Knowledge

This study introduces a novel model to explore the negative moderating effects of regional innovation capacity (RIC) and R&D innovation capacity (RDC) on the relationship between ESG performance and TFP. The proposed model (Figure 4) revealed the following key findings:

1. Introduction of negative moderating effects

The model introduces the concept that RIC and RDC do not always positively affect the relationship between ESG performance and TFP. Instead, they can negatively moderate this relationship, which is a novel perspective that has not been extensively explored in existing literature.

2. Resource diversion effect

The model highlights the resource diversion effect, in which a high RIC can lead to a shift in resources and attention away from ESG activities. This insight suggests that regions that are heavily focused on innovation may need to balance their efforts to ensure that ESG activities are not neglected.

3. Priority shift effect

By identifying the priority shift effect, the model shows that a strong emphasis on R&D innovation capacity may result in companies deprioritizing ESG efforts. This finding underscores the need for a balanced approach to fostering innovation while maintaining commitment to ESG practices.

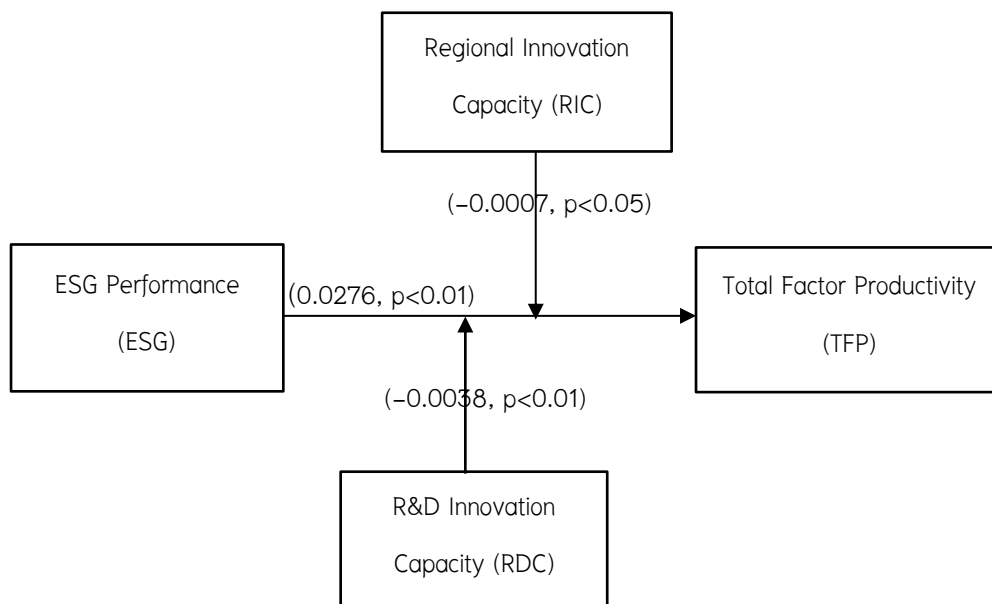


Figure 4 Proposed Model of ESG, TFP, RIC, and RDC Interactions

Through these findings, this study not only deepens the understanding of the complex relationships between ESG, TFP, RIC, and RDC but also provides new managerial insights for companies and policymakers. This emphasizes the need to balance resource allocation between innovation and ESG activities to ensure comprehensive and sustainable development.

Conclusions

This study confirms that ESG performance significantly improves TFP. However, both regional and corporate R&D innovation capacity negatively moderate the effect of ESG performance on TFP. While higher regional and corporate R&D innovation capacities can offer competitive advantages, they may also disperse resources, thereby weakening the positive effect of ESG on TFP. These insights underscore the importance of strategic resource allocation and balanced innovation efforts to maximize the benefits of ESG performance in enhancing TFP.

Recommendations and Limitations

Recommendations

First, Strategic Integration of ESG Practices for Enhanced TFP. Research Objective 1 demonstrates that ESG performance significantly boosts TFP. Therefore, companies should integrate ESG practices into their core operations to optimize resource utilization, strengthen stakeholder engagement, and improve market perceptions. This strategic alignment not only enhances production efficiency but also supports long-term sustainability and competitiveness. Policymakers are encouraged to incentivize such integration through tax breaks, subsidies, or recognition programs to amplify ESG's positive effects on TFP.

Second, Managing Regional Innovation Capacities. Research Objective 2 reveals that strong regional innovation capacities can negatively moderate the ESG–TFP relationship. Companies in these regions should adopt targeted resource allocation strategies to ensure that ESG initiatives are not overshadowed by other innovation-driven activities. Policymakers should provide targeted support, such as grants or incentives, to help balance innovation efforts with sustainable development goals.

Third, Balancing R&D Innovation with ESG Commitments. Research Objective 3 indicates that corporate R&D innovation capacities could weaken the effect of ESG on TFP if not properly balanced. Companies must align short-term R&D objectives with long-term ESG commitments to sustain the

positive effects of ESG on TFP. Strengthening stakeholder communication is crucial to ensure a shared understanding of the importance of both innovation and sustainability. Policymakers should establish guidelines that encourage this balance, supporting both immediate innovation outcomes and long-term ESG goals.

To maximize the positive effect of ESG on TFP, particularly in regions with strong innovation capacities, it is essential to strategically allocate resources, implement targeted policy support, and ensure robust stakeholder engagement. These strategies will help companies effectively balance innovation and sustainability, leading to enhanced productivity and long-term success.

Limitations and future research directions

The generalizability of this study may be limited by sample selection and data availability, with moderating effects in industry and company-specific contexts that have not been fully considered. Future research should expand these explorations within a broader institutional framework and use nonlinear models to study the potential inverted U-shaped effects. Additionally, analyzing the relationship between innovation capacity, ESG performance, and TFP in more detail by incorporating factors such as industry characteristics, corporate governance, and the degree of digital transformation can provide deeper insights.

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