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A STUDY ON THE IMPACT OF ESG PERFORMANCE, CORPORATE RESILIENCE ON TOTAL FACTOR PRODUCTIVITY

The aim of this study is to examine the impact of total factor productivity (TFP) on corporate performance, considering the sustainability of the company, including its ESG (Environmental, Social, and Governance) indicators, which have a significant influence on TFP. In a global environment marked by uncertainty, companies with high ESG scores demonstrate greater adaptability and resource allocation efficiency, contributing to the growth of TFP.

Based on a rich sample of Chinese listed companies from 2010 to 2023, this study constructs a multiple regression fixed-effects model and conducts an empirical study using panel data. At the same time, we use multiple methods for robustness testing to ensure the reliability of the research results. The findings indicate that ESG has a positive effect on TFP, with corporate sustainability playing a mediating role through innovation capabilities, operational resilience, organizational resilience, and financial flexibility. Furthermore, significant differences are observed in the impact of ESG between companies with high market concentration, capital-intensive industries, high-pollution industries, and others. The study emphasizes the need for companies to develop resilience and innovation capabilities to enhance productivity and sustainability.

Key words: ESG, Corporate Resilience, Operational Resilience, Financial Flexibility, Total Factor Productivity.

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ESG көрсеткіштері мен корпоративтік тұрақтылықтың жалпы факторлық өнімділікке әсерін зерттеу

Зерттеудің мақсаты – жалпы факторлық өнімділіктің (ЖФӨ) компанияның тиімділігіне әсерін зерттеу, сонымен қатар компанияның орнықтылығын, оның ішінде ЖФӨ-ге елеулі әсер ететін ESG (экологиялық, әлеуметтік және корпоративтік басқару) көрсеткіштерін ескеру. Белгісіздікке толы жаһандық ортада ESG көрсеткіштері жоғары компаниялар икемділік пен ресурстарды тиімді бөлу қабілеті арқылы ЖФӨ-нің өсуіне ықпал етеді.

Бұл зерттеу 2010–2023 жылдар аралығындағы Қытайдың биржаға тіркелген компанияларының кең көлемді үлгісіне сүйене отырып, бірнеше регрессиялық тұрақты әсерлер моделін құрастырады және панельдік деректерге эмпирикалық талдау жүргізеді. Сонымен қатар зерттеу нәтижелерінің сенімділігін қамтамасыз ету мақсатында бірнеше тұрақтылық тестілеу әдістері қолданылады.

Зерттеу нәтижелері ESG көрсеткіштері мен ЖФӨ арасындағы оң байланысты көрсетеді. Бұл ретте, компанияның орнықтылығы – инновациялық әлеует, операциялық тұрақтылық, ұйымдық икемділік және қаржылық икемділік арқылы делдал рөл атқарады. Бұдан бөлек, ESG көрсеткіштерінің әсері нарықтық шоғырлану деңгейі жоғары, капитал сыйымды және экологиялық тұрғыдан зиянды салалардағы компанияларда айтарлықтай ерекшеленетіні анықталды.

Зерттеу компаниялардың өнімділігі мен орнықтылығын арттыру үшін олардың инновациялық және бейімделу қабілеттерін дамыту қажеттігін атап көрсетеді.

Түйін сөздер: ESG, корпоративтік орнықтылық, операциялық тұрақтылық, қаржылық икемділік, жалпы факторлық өнімділік.

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Исследование влияния показателей ESG и корпоративной устойчивости на общую факторную производительность

Цель данного исследования – изучить влияние совокупной факторной производительности (СФП) на корпоративную эффективность с учетом устойчивости компании, включая ее ESG-показатели (экологические, социальные и управленческие), которые оказывают значительное влияние на СФП. В условиях глобальной неопределенности компании с высокими ESG-оценками демонстрируют лучшую адаптивность и эффективность распределения ресурсов, способствуя росту СФП.

На основе обширной выборки китайских публичных компаний за 2010–2023 годы в исследовании построена модель множественной регрессии с фиксированными эффектами и проведен эмпирический анализ с использованием панельных данных. Одновременно для обеспечения надежности результатов исследования применяются различные методы проверки устойчивости.

Результаты показывают, что ESG положительно влияет на СФП, при этом устойчивость компании опосредует это влияние через инновационный потенциал, операционную устойчивость, организационную гибкость и финансовую маневренность. Кроме того, выявлены значительные различия во влиянии ESG в зависимости от уровня рыночной концентрации, капиталоемкости отрасли и уровня загрязнения окружающей среды.

Исследование подчеркивает необходимость развития адаптивности и инновационного потенциала компаний для повышения их производительности и устойчивости.

Ключевые слова: ESG, корпоративная устойчивость, операционная устойчивость, финансовая гибкость, совокупная факторная производительность.

Introduction

Against the backdrop of a changing global environment and increasing attention to social responsibility, companies are facing more complex challenges in their production and operations. Factors, like Economic volatility, policy uncertainties, limited resources, and the growing expectations from consumers and investors regarding corporate social responsibility, require companies to enhance their competitiveness while taking on greater environmental and social responsibilities. Environmental, social and corporate governance (ESG) performance has emerged as a key driver of corporate sustainability. ESG performance not only reflects a company's level of social responsibility, corporate branding and governance, but also plays an important role in operational efficiency and organisational effectiveness. In recent years, ESG performance has come to be seen as an important reflection of a company's operational efficiency and overall management capabilities.

Moreover,total factor productivity (TFP) is a core indicator for evaluating the productivity and competitiveness of enterprises. At the same time, TFP also reflects the comprehensive capabilities of an enterprise in terms of technological innovation, operational efficiency and managerial competence. In view of the important role of ESG and TFP in enterprise management, the relationship between ESG and TFP has increasingly received attention and research from academics and the business community. Research has shown that good ESG performance enhances the risk resilience of enterprises, thereby increasing TFP.

In the globalised market competition, improving TFP is a key initiative for enterprises to achieve sustainable development. Firms' developmental resilience is mainly reflected in their ability to innovate, supply chain stability, organisational adaptability and financial flexibility. Therefore, examining how ESG performance affects TFP and how ESG affects various dimensions of corporate resilience will ultimately improve TFP. In order to explore these topics in depth, this paper analyses the role of corporate resilience in the relationship between the two from an innovative perspective, constructing an impact mechanism from operational resilience, organisational resilience and financial resilience, further enriching the study of ESG impact mechanisms. This not only provides theoretical insights for enterprises to formulate effective strategies, but also provides references to support enterprises to achieve long-term competitive advantages and sustainable development in dynamic market environments.

This paper selects China's A-share listed companies from 2010 to 2023 as the research sample, and the rich sample provides sufficient conditions for the study. TFP is measured using the LP method, and the impact and mechanism of ESG performance

on TFP are systematically investigated. The study finds that (1) ESG performance has a significant impact on total factor productivity; (2) ESG performance improves TFP through the key mechanism of corporate resilience. Further, we investigate the heterogeneity of TFP based on industry characteristics.

The possible contributions of this paper are summarised in two main areas:

The first is the expansion of impact mechanisms. This paper explores the impact mechanism of ESG on TFP from the perspective of corporate resilience. In contrast to existing literature focusing on innovation capacity, technological progress, corporate governance, and management efficiency, this paper introduces operational resilience and financial flexibility as new mediating variables. It reveals how companies improve long-term productivity by enhancing resilience. This perspective enriches the research related to ESG impact mechanisms.

The second is deepening heterogeneity analysis. This paper further investigates the heterogeneity of the ESG-TFP relationship based on industry characteristics, especially focusing on the differentiation effects in industries with high market concentration, heavy assets, and heavy pollution. By examining these industries, the paper reveals how ESG practices impact TFP in different ways depending on the industry context. To further enrich the research on industry differences in the impact of ESG on TFP, and to provide lessons and references for subsequent ongoing research.

Literature review

ESG Performance and Total Factor Productivity

ESG performance refers to a company's environmental, social and governance (ESG) performance, which is the standard by which corporate sustainability and social responsibility are assessed. It serves as a benchmark for evaluating corporate sustainability and social responsibility. Total Factor Productivity (TFP) is a company's production efficiency indicator. It reflects its ability to enhance output through technological advancement and management innovation under unchanged input factors (e.g., capital, labor, technology). TFP represents the portion of output not directly explained by input factors and is generally considered an embodiment of technological progress and managerial innovation (Solow,1957). ESG performance is rooted in social responsibility theory and has evolved into a multidimensional and systematic framework. Early ESG research primarily focused on social and environmental aspects. With the rise of sustainable development principles, scholars have recognized that ESG is not only linked to corporate social responsibility and brand image but also closely associated with operational efficiency, risk management, resource integration, and competitive advantage enhancement. Recent studies have increasingly focused on the relationship between ESG performance and TFP, especially in corporate innovation, resource allocation efficiency, and risk management. Specifically, different dimensions of ESG affect corporate TFP through the following mechanisms.

In recent years, scholars have paid increasing attention to the potential impact of environmental factors on corporate productivity. Environmental performance refers to a company's efficiency in reducing pollution emissions and optimizing resource use during production.Enterprises can improve productivity through environmentally friendly technologies. It has been found that corporate environmental responsibility promotes TFP (Cao & Xu, 2024). Excellent social responsibility makes firms better able to cope with external pressures (Vallaster, 2017). ESG performance improves TFP for a firm's downstream customers (Yang et al., 2024).

Research has shown that corporate social responsibility (CSR) can increase TFP in a number of ways. CSR performance tends to be closely related to technological innovation, employee motivation and brand reputation. There have been more studies on the relationship between social responsibility and TFP. There is a positive correlation between CSR and TFP (Edmans, 2011). Enterprises increase TFP when they fulfil their social responsibilities (Li & Cao, 2025). The Relationship between CSR and Performance (Cho et al., 2019). The relationship between corporate environmental responsibility and TFP has been further explored (Ding et al., 2024).

Corporate governance structure and level of governance also have a significant impact on the TFP of firms. A sound governance structure reduces agency costs and business risks, optimises resource allocation and improves operational efficiency. Enterprises with good governance structures and mechanisms are more likely to incorporate ESG into their operations and management, thereby increasing TFP (Xiong et al., 2024). Rational incentives significantly increase TFP (Li et al., 2024). ESG performance improves firms'TFP by increasing investment efficiency (Ge et al., 2024).

In this research project, we have chosen China, the largest emerging market economy, as a sample to study how environmental, social and corporate governance performance affects TFP from a broad-

er perspective and diverse industries. Therefore, we propose the following research hypotheses:

Hypothesis 1: ESG performance enhances corporate TFP.

ESG Performance, Corporate Resilience and Total Factor Productivity

Corporate resilience refers to the ability of an enterprise to recover quickly and achieve normal development when it is faced with the impact of major events such as macro-environmental changes, technological changes and natural disasters. With the fierce competition in the global market and significant changes in the environment, enterprise resilience has become an important criterion for measuring whether enterprises can operate stably and have long-term competitive advantages. Based on relevant research, it is possible to summarise the mechanisms by which corporate resilience affects TFP and explore its relationship with environmental, social and governance (ESG) performance.

In recent years, scholars have been actively researching the relationship between corporate resilience and environmental, social and governance (ESG) performance.Proactive environmental practices by enterprises can enhance adaptive capacity and survivability, especially when faced with major environmental changes or climate event shocks, and help enterprises minimise losses and resume normal production and operations. It has been shown that firms with higher social responsibility performance are more resilient (Huang et al., 2020). Excellent ESG performance improves total factor productivity (Lu et al., 2020).

Corporate resilience has an important impact on TFP. Innovation capability is the core ability of enterprises to be resilient and to achieve sustainable development, and enterprises with good innovation capability can maintain technological leadership in the market, while enterprises with innovation capability tend to have excellent operation management and business performance. The ability to innovate not only enhances TFP directly, but also contributes to TFP indirectly through capital (Ma et al., 2022).

Operational resilience of an enterprise is a guarantee for achieving healthy operations. The operational management of the supply chain system is the organisational ability of the core enterprise to manage upstream and downstream enterprises, reflecting the core enterprise's position in the industry. When an enterprise faces major changes in the market, having a stable and strong supply chain system can ensure the continuity and stability of the enterprise's production. The more stable an enterprise's supply chain is, the higher its TFP will be (Liu & Wang, 2024). Firms with resilient supply chains can contribute to business growth by increasing TFP (Lin & Li, 2025).

Financial resilience plays an important role in improving TFP. Good financial resilience indicates that an organisation's financial position is at a relatively healthy level, with sufficient financial strength to invest and sufficient financial resources to support business development and operations management. Enterprises with strong financial resilience are able to respond quickly to changes in the market and drive sustained productivity growth (Cheong et al., 2024). In addition, strong organisational resilience is another key factor for enterprises to improve TFP. Through an efficient organisational structure and excellent operational systems, companies can coordinate resources efficiently and improve overall operational efficiency.

Building on existing research and considering the unique context of Chinese enterprises in emerging markets, This paper provides insights into the impact of ESG performance on TFP. It specifically reveals how ESG performance contributes to TFP growth through pathways such as technological innovation, operational resilience, and financial flexibility. Based on the above theoretical analyses, the following basic assumptions are made in this paper:

Hypothesis 2: ESG performance enhances a company's TFP by improving innovation capabilities.

Hypothesis 3: ESG performance enhances a company's TFP by improving operational resilience.

Hypothesis 4: ESG performance enhances a company's TFP by improving organizational resilience.

Hypothesis 5: ESG performance enhances a company's TFP by improving financial flexibility.

Methodology

Dependent Variables

Total Factor Productivity (TFP) is the dependent variable. The current main methods for calculating TFP include Ordinary Least Squares (OLS), Fixed Effects (FE) ,Levinsohn-Petrin (LP), Generalized Method of Moments (GMM), Olley-Pakes (OP), and these five TFP indicators are calculated by adapting the method proposed by (Lu & Lian, 2012). Given that the LP addresses endogeneity problems through intermediate inputs, it provides more accurate estimates of TFP. Therefore, the LP, as referenced in (Zhu et al., 2024), is adapted to calculate TFP (denoted as TFP_LP) as the dependent variable. In

subsequent robustness tests, TFP calculated by using the OLS (TFP_OLS) and the FE (TFP_FE) are employed as alternatives.

Independent Variable

ESG is the core independent variable. This study adopts Huazheng ESG ratings as a proxy variable for corporate ESG performance. Sino-Securities Index Information Service (Shanghai) Co.Ltd is a company specialising in ESG ratings and providing investment services, and its ESG ratings cover all A-share listed companies in China, making it a more recognised ESG rating company in the industry and academia.

Control Variables

At the firm level, micro control variables that may influence TFP include Lnsize, Lev, ROA, ATO, Cash, Growth, MO, and TOP. T Variables are defined in Table 1.

Table 1 – Definition of variables

Variables	Deffnitions
TFP_LP	Calculation of TFP using the LP
ESG	Sino-Securities Index ESG
Lnsize	Logarithm of total enterprise assets
Lev	Asset-liability ratio
ROA	Net Profit/Total Assets
ATO	Operating income/Average total assets
Cash	Net operating cash flow/total assets
Growth	$(Sales_{i,t}\text{-}Sales_{i,t-1})/Sales_{i,t-1}$
MO	Number of shares held by management/Total shares
TOP	Shareholding of the top shareholder/ total shares
Note – In this study, the authors defined the variables.	

Sample Selection and Data Sources

In order to make the research sample representative enough, all A-share listed companies in China from 2010 to 2023 are selected in this paper, except for financial industry, ST companies and delisted companies. The sample covers a wide range of industries including machinery manufacturing, aerospace, information technology, power, road transport, pharmaceuticals, non-ferrous metals, chemicals, agriculture, retail and many others. The range of sample periods covers a 14-year period from 2010-2023, and the rich and heterogeneous sample provides favourable conditions for the study. All variables of the firms are obtained from the China Securities Market and Accounting Research Database (CSMAR), except for the indicators of ESG and TFP. To further control for bias in the estimates, we winsorized all enterprise control variables at the 1st and 99th percentiles, and regression analyses were performed in this study using Stata software.

Model Specifications and Estimation Method

This study examines the impact of ESG on TFP using a fixed effects model to regress the panel data of listed companies. The benchmark regression model is as follows:

$$TFP\_LP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Lnsize_{i,t} + \\ + \beta_3 Lev_{i,t} + \beta_4 ROA_{i,t} + \beta_5 ATO_{i,t} + \beta_6 Cash_{i,t} + \\ + \beta_7 Growth_{i,t} + \beta_8 MO_{i,t} + \beta_9 TOP_{i,t} + \\ + V_i + Year_t + \varepsilon_{i,t} \quad (1)$$

Where $TFP\_LP_{i,t}$ is the dependent variable, representing the TFP indicator for firm i in year t, and $ESG_{i,t}$ is the ESG performance score for firm i in year t. Eight enterprise control variables are included: Lnsize, Lev, ROA, ATO, Cash, Growth, MO, and TOP. V represents enterprise fixed effects, Year represents time fixed effects, and $\varepsilon_{i,t}$ is the error term.

Descriptive Statistics

Descriptive statistics are represented in Table 2 for the main variables, showing that the mean, standard deviation, and median of TFP_LP are 8.3580, 1.0797, and 8.2582, respectively, indicating some variation in TFP across different enterprises. The mean, standard deviation, and median of ESG are 73.1941, 5.0304, and 73.4200, respectively, in which the relatively large standard deviation suggests significant variation in ESG performance among different enterprises.

Table 2 – Descriptive Statistics

Variables	N	Mean	p50	SD	Min	Max
TFP_LP	38923	8.3580	8.2582	1.0797	3.9201	13.1064
ESG	42256	73.1941	73.4200	5.0304	36.6200	92.9300
Lnsize	43328	22.1624	21.9600	1.3110	19.7200	26.2400
Lev	43328	0.4146	0.4033	0.2103	0.0502	0.9252
ROA	43328	0.0365	0.0381	0.0642	-0.2601	0.2001
ATO	43315	0.6059	0.5147	0.4101	0.0765	2.4788
Cash	43328	0.0469	0.0465	0.0691	-0.1623	0.2425
Growth	43131	0.3457	0.1188	0.9293	-0.6813	6.5221
MO	42075	14.7539	1.3647	20.2401	0.0000	69.0864
TOP	43275	34.0994	31.8306	14.8952	8.4498	74.4510
Note – compiled by the authors based on the CSMAR sample.						

Correlation Analysis

Without considering other factors, the correlation coefficient between ESG and TFP is 0.22, which is statistically significant at the 1% level, indicating a positive relationship between the two, according to Pearson correlation analysis in Table 3. Other potential influencing factors will be controlled in subsequent robustness tests and heterogeneity analysis. In addition, the correlation coefficients of most control variables are below 0.5, indicating that there is no issue of multicollinearity in the model.

Table 3 – Correlation Analysis

Variables	TFP_LP	ESG	Lnsize	Lev	ROA	ATO	Cash	Growth	MO	TOP
TFP_LP	1									
ESG	0.22***	1								
Lnsize	0.79***	0.23***	1							
Lev	0.43***	-0.13***	0.46***	1						
ROA	0.14***	0.22***	0.04***	-0.36***	1					
ATO	0.55***	0.01**	0.07***	0.17***	0.13***	1				
Cash	0.11***	0.11***	0.09***	-0.17***	0.41***	0.12***	1			
Growth	-0.02***	-0.01	-0.00	0.07***	-0.01	-0.15***	-0.10***	1		
MO	-0.24***	0.09***	-0.32***	-0.31***	0.14***	-0.07***	0.02***	-0.04***	1	
TOP	0.17***	0.09***	0.18***	0.03***	0.15***	0.08***	0.10***	0.01*	-0.07***	1
Note – The authors analysed the samples based on CSMAR using Stata software.										

Results and Discussion

Benchmark Regression Results

Stata statistical software is applied for the regression analysis. Table 4 presents the results of the benchmark regression on the impact of ESG performance on TFP. In column (1), without control variables, ESG performance shows a significant positive correlation with TFP. In column (2), ESG performance remains significantly positively correlated with TFP when control variables are included but individual and time-fixed effects are excluded. In column (3), the impact of ESG performance on TFP remains significantly positive after including control variables and controlling for individual and time-fixed effects. The impact of ESG performance on TFP is significantly positive at the 1% level in these three scenarios, indicating that the empirical results are supportive of the fundamental hypotheses and conclusions.

Table 4 – Benchmark Regression Results

Variables	TFP_LP	TFP_LP	TFP_LP
	(1)	(2)	(3)
ESG	0.0113***	0.0066***	0.0018***
	[0.0011]	[0.0008]	[0.0005]
Lnsize		0.6255***	0.6473***
		[0.0051]	[0.0085]
Lev		0.1582***	0.0259
		[0.0343]	[0.0317]
ROA		1.0378***	0.8605***
		[0.0692]	[0.0471]
ATO		1.2973***	1.2634***
		[0.0204]	[0.0217]
Cash		-0.5454***	0.0751**
		[0.0530]	[0.0364]
Growth		0.0583***	0.0066*
		[0.0054]	[0.0035]
MO		0.0022***	0.0007**
		[0.0002]	[0.0003]
TOP		-0.0012***	0.0000
		[0.0003]	[0.0005]
_cons	7.5357***	-6.9178***	-7.0006***
	[0.0777]	[0.1146]	[0.1889]
Firm FE	YES	NO	YES
Year FE	YES	NO	YES
N	38166	37461	37050
adj. R^2	0.8401	0.8829	0.9594
F	113.6426	3.2e+03	1.2e+03

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Note – Compiled by the authors based on CSMAR sample data

Robustness Tests

Replacing Dependent Variable

For robustness considerations, TFP calculated by the OLS (TFP_OLS) and by the FE (TFP_FE) is selected as an alternative dependent variable, and performs regression tests with ESG performance against TFP_OLS and TFP_FE. Following the approach used in the benchmark regression, three methods are applied: (1) without control variables; (2) without controlling for individual and time-fixed effects; (3) with all control variables included and controlling for individual and time-fixed effects.

The results in Table 5 show that the impact of ESG performance on TFP_OLS and TFP_FE is significantly positive at the 1% level in using these three methods, indicating that the conclusion is reliable. The detailed results are presented in Table 5.

Including Lagged Dependent Variable

Considering that the total factor productivity of the previous period may have an impact on the total factor productivity of the current period, the lagged dependent variable was included and regression tests were conducted to eliminate the potential effect of correlation between the dependent variables in different periods. The results in table 6 show that ESG performance positively affects TFP at the 10 per cent level, indicating that the findings are robust.

Table 5 – Replacement of dependent variable regression results

Variables	TFP_OLS	TFP_OLS	TFP_OLS	TFP_FE	TFP_FE	TFP_FE
	(1)	(2)	(3)	(4)	(5)	(6)
ESG	0.0571***	0.0040***	0.0018***	0.0144***	0.0039***	0.0020***
	[0.0030]	[0.0006]	[0.0004]	[0.0012]	[0.0006]	[0.0004]
Lnsize		0.8218***	0.8320***		0.8821***	0.8912***
		[0.0043]	[0.0080]		[0.0044]	[0.0085]
Lev		0.1631***	0.0746***		0.1679***	0.0907***
		[0.0259]	[0.0272]		[0.0263]	[0.0282]
ROA		0.7621***	0.6416***		0.7092***	0.5844***
		[0.0519]	[0.0412]		[0.0522]	[0.0421]
ATO		1.2949***	1.2697***		1.3191***	1.2851***
		[0.0176]	[0.0209]		[0.0183]	[0.0216]
Cash		0.1343***	0.2236***		0.2993***	0.2531***
		[0.0401]	[0.0316]		[0.0404]	[0.0319]
Growth		-0.0001	-0.0010		-0.0146***	-0.0032
		[0.0031]	[0.0030]		[0.0031]	[0.0030]
MO		0.0014***	0.0006***		0.0014***	0.0006**
		[0.0002]	[0.0002]		[0.0002]	[0.0002]
TOP		-0.0003	0.0005		-0.0001	0.0007*
		[0.0002]	[0.0004]		[0.0002]	[0.0004]
_cons	6.4569***	-8.8420***	-8.8729***	10.2777***	-9.5118***	-9.5409***
	[0.2145]	[0.0977]	[0.1784]	[0.0912]	[0.1012]	[0.1886]
Firm FE	YES	NO	YES	YES	NO	YES
Year FE	YES	NO	YES	YES	NO	YES
N	38578	37461	37050	38166	37461	37050
adj. R^2	0.0520	0.9548	0.9794	0.8694	0.9596	0.9815
F	370.8569	9.4e+03	2.1e+03	132.5682	1.1e+04	2.2e+03
Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1 Note – Compiled by the authors based on CSMAR sample data						

Table 6 – Including Lagged Dependent Variable

Variables	TFP_LP	TFP_LP
	(1)	(2)
ESG	0.0029***	0.0009*
	[0.0006]	[0.0004]
TFP_LP_1	0.6996***	0.2759***
	[0.0082]	[0.0109]
Lnsize		0.4878***
		[0.0097]
Lev		0.0886***
		[0.0259]
ROA		0.9548***

Continuation of the table

		[0.0428]
ATO		1.0235***
		[0.0232]
Cash		0.0416
		[0.0356]
Growth		0.0251***
		[0.0036]
MO		0.0006**
		[0.0003]
TOP		0.0001
		[0.0004]
_cons	2.3606***	-5.5659***
	[0.0769]	[0.1729]
Firm FE	YES	YES
Year FE	YES	YES
N	33289	32328
adj. R^2	0.9224	0.9674
F	3.7e+03	1.5e+03
Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1 Note – compiled by the authors based on CSMAR sample data		

Excluding Anomalous Samples

The 2020 outbreak of COVID-19 has had a significant impact on all aspects of society and the economy.China implemented measures like remote working, which had a major influence on business operations, to control the rapid spread of the virus. According to related studies, the growth rate of TFP in China dropped to a historical low of 1.91% in 2020 due to the impact of the pandemic. Therefore, the 2020 sample is excluded and the regression analysis on the remaining data is re-conducted, to rule out the interference of major anomalies. As shown in Table 7, ESG performance has a significantly positive effect on TFP at the 1% level in using these three methods: (1) without control variables; (2) without controlling for individual and time-fixed effects; (3) with all control variables included and controlling for individual and time fixed effects, indicating that the conclusion is robust.

Table 7 – Excluding anomalous sample regressions

Variables	TFP_LP	TFP_LP	TFP_LP
	(1)	(2)	(3)
ESG	0.0121***	0.0073***	0.0018***
	[0.0011]	[0.0008]	[0.0006]
Lnsize		0.6261***	0.6486***
		[0.0052]	[0.0085]
Lev		0.1565***	0.0243
		[0.0342]	[0.0317]
ROA		1.0581***	0.8728***
		[0.0714]	[0.0514]

Continuation of the table

ATO		1.2926***	1.2583***
		[0.0204]	[0.0217]
Cash		-0.5792***	0.0557
		[0.0538]	[0.0379]
Growth		0.0572***	0.0059
		[0.0054]	[0.0036]
MO		0.0022***	0.0007**
		[0.0002]	[0.0003]
TOP		-0.0011***	0.0001
		[0.0003]	[0.0005]
_cons	7.4755***	-6.9853***	-7.0301***
	[0.0834]	[0.1158]	[0.1883]
Firm FE	YES	NO	YES
Year FE	YES	NO	YES
N	34853	34265	33851
adj. R^2	0.8375	0.8833	0.9587
F	111.5678	3.2e+03	1.2e+03

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Note – compiled by the authors based on CSMAR sample data

In summary, a series of robustness tests, including replacing the dependent variable, adding lagged terms, and excluding the sample from anomalous years, are applied to address potential major factors that could influence the empirical study. All these robustness tests bring empirical results that still support the hypotheses and conclusions, further validating the robustness of the findings.

Mechanism testing

We delved into it further to understand how ESG performance influences TFP with the four mechanisms for measurement which are Innovation, Operational Resilience, Resilience, and Financial Flexibility. Taking the research of (Quan et al., 2017) as a reference, this paper defines the indicator of innovation ability (Innovation) as the natural logarithm of the total number of applications for invention patents, utility models, and design patents plus one. The larger this indicator is, the stronger the enterprise's innovation capability is. Taking the researches of (Bray & Mendelson, 2012) and (Liu et al., 2024) as a reference, it defines the indicator of operational resilience (Supply Chain) as the degree of deviation between an enterprise's production fluctuations and demand fluctuations and uses it to measure the risk of the supply chain. The larger this indicator is, the higher the risk of the enterprise's supply chain is which means that the enterprise enjoys weaker operational resilience, and vice versa. Taking the research of (Lv et al., 2019) as a reference, it defines the indicator of the organization resilience (Resilience) as the overall rating of performance growth measured by the cumulative increase in sales revenue over 3 years and volatility measured by the standard deviation of monthly stock returns within the year, and the rating is calculated in the Entropy Method. The larger this indicator is, the stronger the enterprise's organization resilience is. Taking the research of (Zeng et al., 2013) as a reference, it defines financial flexibility (Flexibility) as an indicator measuring the resilience of an enterprise in managing financial business, financing, and other resources. According to the research, Financial Flexibility equals Cash Flexibility plus Debt Financing Flexibility; Cash Flexibility equals Cash Ratio minus Industrial Cash Ratio; Debt Financing Flexibility equals Max (0, Industry Average Debt Ratio minus Liability Ratio). The larger this indicator is, the stronger the enterprise's financial flexibility is. The empirical models of the four mechanisms for measurement are as follows:

$$Innovation_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Lnsize_{i,t} + \\ + \beta_3 Lev_{i,t} + \beta_4 ROA_{i,t} + \beta_5 ATO_{i,t} + \beta_6 Cash_{i,t} + \\ + \beta_7 Growth_{i,t} + \beta_8 MO_{i,t} + \beta_9 TOP_{i,t} + V_i + \\ Year_t + \varepsilon_{i,t} \quad (4)$$

$$Supplychain_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Lnsize_{i,t} + \\ + \beta_3 Lev_{i,t} + \beta_4 ROA_{i,t} + \beta_5 ATO_{i,t} + \beta_6 Cash_{i,t} + \\ + \beta_7 Growth_{i,t} + \beta_8 MO_{i,t} + \beta_9 TOP_{i,t} + \\ + V_i + Year_t + \varepsilon_{i,t} \quad (5)$$

$$Resilience_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Lnsize_{i,t} + \\ + \beta_3 Lev_{i,t} + \beta_4 ROA_{i,t} + \beta_5 ATO_{i,t} + \beta_6 Cash_{i,t} + \\ + \beta_7 Growth_{i,t} + \beta_8 MO_{i,t} + \beta_9 TOP_{i,t} + V_i + \\ + Year_t + \varepsilon_{i,t} \quad (6)$$

$$Flexibility_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Lnsize_{i,t} + \\ + \beta_3 Lev_{i,t} + \beta_4 ROA_{i,t} + \beta_5 ATO_{i,t} + \beta_6 Cash_{i,t} + \\ + \beta_7 Growth_{i,t} + \beta_8 MO_{i,t} + \beta_9 TOP_{i,t} + \\ + V_i + Year_t + \varepsilon_{i,t} \quad (7)$$

$Innovation_{i,t}$, $Supplychain_{i,t}$, $Resilience_{i,t}$, and $Flexibility_{i,t}$ are dependent variables that stand for the innovation ability (Innovation), operational resilience (Supply Chain), organization resilience (Resilience), and financial flexibility (Flexibility) respectively of the enterprise i in the t-th year, and $ESG_{i,t}$ measures the ESG performance of the enterprise i in the t-th year. Eight enterprise-level control variables are set, including Lnsize, Lev, ROA, ATO, Cash, Growth, MO, and TOP. V stands for Firm Fixed Effects, Year stands for Time Fixed Effects, and $\varepsilon_{i,t}$ stands for Standard Error Term.

According to the Regression Output in the table below, it can be seen that ESG performance has a great influence on Innovation, Supply Chain, and Resilience at 1% and on Flexibility at 5%. It demonstrates that ESG performance encourages the improvement of the enterprise's innovation ability, decreases the risk of the supply chain, increases operational resilience, and improves organization resilience and financial flexibility. The empirical result supports the assumption and conclusion of the mechanisms of measurement. Details are shown in Table 8.

Table 8 – Mechanism test results

Variables	Innovation	Supplychain	Resilience	Flexibility
	(1)	(2)	(3)	(4)
ESG	0.0069***	-0.0011***	0.0004***	0.0005**
	[0.0017]	[0.0004]	[0.0001]	[0.0002]
Lnsize	0.4996***	0.0175***	0.0062***	-0.0046
	[0.0259]	[0.0047]	[0.0008]	[0.0033]
Lev	-0.1587*	0.0593***	-0.0160***	-0.6904***
	[0.0842]	[0.0181]	[0.0028]	[0.0137]
ROA	0.0135	0.0112	-0.0316***	0.0316*
	[0.1413]	[0.0336]	[0.0062]	[0.0184]
ATO	0.0912*	-0.0023	0.0066***	-0.0453***
	[0.0497]	[0.0069]	[0.0020]	[0.0061]
Cash	-0.1996**	0.2501***	-0.0040	0.2068***
	[0.0990]	[0.0317]	[0.0041]	[0.0139]
Growth	-0.0114	-0.0139***	-0.0004	0.0016
	[0.0081]	[0.0032]	[0.0004]	[0.0010]
MO	0.0031***	-0.0016***	-0.0000	0.0007***
	[0.0010]	[0.0002]	[0.0000]	[0.0001]
TOP	0.0007	-0.0007***	0.0001***	0.0003
	[0.0016]	[0.0003]	[0.0000]	[0.0002]

Continuation of the table

Variables	Innovation	Supplychain	Resilience	Flexibility
	(1)	(2)	(3)	(4)
_cons	-8.9502***	0.6372***	0.3353***	0.4337***
	[0.5747]	[0.1044]	[0.0181]	[0.0732]
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	39773	37053	31332	39773
adj. R^2	0.7464	0.2219	0.9863	0.6869
F	50.9498	25.2849	17.0339	419.4327

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Note – Compiled by the authors based on CSMAR sample data

Heterogeneity Analysis

We analyzed the different characteristics within the sample a step further to delve into the non-homogeneous impact of ESG on TFP. Analyzing from the perspective of industrial competition and market concentration, we, taking the Herfindahl-Hirschman Index 0.3 as the watershed, listed samples bigger or equal to 0.3 as high market concentration ones and those smaller than 0.3 as low market concentration ones. We found that in the high market concentration group, ESG performance has a subtle impact on TFP, while in the other group, the impact is salient. One possible explanation is that in a high market concentration environment lacking competitiveness, enterprises see insufficient motivation to improve their ESG performance because of a light burden of competitiveness. The high market concentration may lead to a lower resource allocation efficiency and the leading enterprises may prefer using currently available resources and upgraded technologies instead of innovation to improve their operation and supply chain, and therefore develop their ESG performance and TFP greatly. Details are shown in the columns (1) and (2) of Table 9.

Referring to the research of (Yin et al., 2018) and according to the *Guidelines on Industry Classification of Listed Companies* by the China Securities Regulatory Commission revised in 2012, this paper classifies the samples as technology-intensive enterprises, labor-intensive enterprises, and asset-intensive enterprises by the intensity of production factors. Analyzing from the perspective of production factors, the ESG performance of asset-intensive enterprises has a subtle impact on TFP while that of non-asset-intensive enterprises, including technology-intensive enterprises and labor-intensive enterprises, has a salient impact on TFP. One possible explanation is that as the operation of asset-intensive enterprises is usually related to a large amount of fixed-asset investment with a long payback period, and as their higher leverage rate leads to a lower Return on Equity (ROE), the improvement of their TFP is curbed. Details are shown in columns (3) and (4) of Table 9.

Referring to the research of (Wang et al., 2021) and according to the *Guidelines on Industry Classification of Listed Companies* by China Securities Regulatory Commission revised in 2012, this paper lists 15 sectors, including Coal mining and dressing, Petroleum and natural gas extraction, Non-ferrous metal ore mining, and Textile, as main polluted industry trades. Analyzing from the perspective of the degree of environmental pollution, the ESG performance of the enterprises in the main polluted industry trades has a subtle impact on TFP while that of the enterprises that are out of the main polluted industry trades has a salient positive impact on TFP. One possible explanation is that in the main polluted industry trades, the ESG performance is constrained by environmental rules, technological innovation, and other factors and thus finds it difficult to improve TFP. Details are shown in the columns (5) and (6) of Table 9.

Table 9 – Heterogeneity Analysis

Variables	HHI		Asset-intensive		Heavy-pollution	
	High	Low	YES	NO	YES	NO
	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_LP	TFP_LP	TFP_LP	TFP_LP	TFP_LP	TFP_LP
ESG	0.0007	0.0022***	0.0002	0.0023***	0.0014	0.0020***
	[0.0014]	[0.0005]	[0.0008]	[0.0006]	[0.0009]	[0.0006]
Lnsize	0.6567***	0.6417***	0.6237***	0.6544***	0.6019***	0.6546***
	[0.0176]	[0.0093]	[0.0160]	[0.0102]	[0.0122]	[0.0107]
Lev	-0.0146	0.0411	-0.1358***	0.0640*	-0.1613***	0.0953**
	[0.0746]	[0.0321]	[0.0460]	[0.0371]	[0.0394]	[0.0386]
ROA	0.7849***	0.8727***	0.6126***	0.9170***	0.6935***	0.9100***
	[0.0985]	[0.0531]	[0.0982]	[0.0531]	[0.0817]	[0.0542]
ATO	1.2619***	1.2645***	1.2214***	1.2698***	1.1258***	1.2957***
	[0.0485]	[0.0234]	[0.0422]	[0.0246]	[0.0337]	[0.0275]
Cash	0.0696	0.0871**	0.0101	0.1050***	0.0276	0.1039**
	[0.0947]	[0.0377]	[0.0850]	[0.0381]	[0.0671]	[0.0415]
Growth	0.0125*	0.0053	-0.0135	0.0086**	-0.0107	0.0098**
	[0.0072]	[0.0039]	[0.0086]	[0.0038]	[0.0076]	[0.0039]
MO	0.0006	0.0006*	0.0011**	0.0006*	0.0012***	0.0005
	[0.0011]	[0.0003]	[0.0005]	[0.0004]	[0.0005]	[0.0004]
TOP	-0.0012	0.0003	0.0005	0.0000	0.0002	-0.0000
	[0.0013]	[0.0005]	[0.0008]	[0.0006]	[0.0008]	[0.0006]
_cons	-7.0841***	-6.9214***	-6.3954***	-7.1905***	-5.9067***	-7.1896***
	[0.3870]	[0.2086]	[0.3755]	[0.2270]	[0.2877]	[0.2365]
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	7383	29334	6736	30290	8582	28443
adj. R^2	0.9481	0.9643	0.9675	0.9599	0.9689	0.9594
F	246.9663	1.0e+03	277.2851	904.7567	369.5859	824.7087

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Note – Compiled by the authors based on CSMAR sample data

Conclusion

Addressing the unique context of emerging market economies, this paper systematically investigates the relationship between ESG performance and TFP based on a sample of Chinese firms from 2010 to 2023, using an empirical research methodology and multiple regression analysis on panel data. The results of the study show that ESG performance increases the TFP of firms. In particular, this study analyses the mechanisms by which firms' ESG performance affects TFP by examining key mechanisms such as innovative capacity, operational and organisational resilience, and financial flexibility, through which ESG performance increases TFP. Further heterogeneity analyses show that the impact of ESG performance on TFP varies between asset-intensive industries, heavily polluting industries, and so on.

This work enriches related research on ESG and total factor productivity. However, there are still some blank areas and research directions on the relationship between ESG and total factor productivity, which can be explored and researched continuously. For example: whether ESG performance has differentiated impacts on TFP of companies with different

ownership properties and enterprises with different life cycles; what other mechanisms are available for the impact of ESG performance on TFP, and so on.

This study highlights the importance and relevance of incorporating environmental, social and governance (ESG) factors into corporate management. As a dynamic economy, Kazakhstan has been actively diversifying its economy in recent years and has made great strides in economic transformation and business development. Kazakhstan has good resource advantages and ESG performance has a significant impact on the long-term value and sustainable development of enterprises. Enterprises can learn from successful experiences and actively promote corporate ESG practices based on their own resource conditions and competitive advantages. They should further improve their corporate governance structure, cultivate innovation capacity, strengthen environmental management and green development, increase TFP through improved ESG performance, and achieve sustainable development.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

Due to the signing of the agreement on non-distribution of primary data, the processed data file can be presented upon the request.

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