Three Essays on Environmental, Social, and Governance and Firm Performance in China

TOHOKU UNIVERSITY

DOCTORAL THESIS

Three Essays on Environmental, Social, and Governance and Firm Performance in China

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Declaration of Authorship

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- Where I have consulted the published work of others, this is always clearly attributed.
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Abstract

Graduate School of Economics and Management

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Three Essays on Environmental, Social, and Governance and Firm Performance in China

by Hui ZHOU

This thesis examines the relationship between the Environmental, Social, and Governance (ESG) levels and firm performance in China. The first chapter investigates the effectiveness of corporate environmental responsibility (CER) engagement on firm value, emphasizing the moderating role of ownership type. The data used are Chinese A-listed firms from 2006 to 2019. The study period is split into a period with a steady institutional background (2006-2015) and a shaky period of environmental reforms (2016-2019) to capture the difference in legal circumstances. The study finds that, first, the impact of CER on firm value changed significantly from negative to positive over the two periods. Second, ownership type played a moderating role that influenced CER effectiveness on firm value. Third, given the environmental reforms, CER effectiveness for state-owned enterprises affiliated with the central government increased the most while that for private enterprises increased the least. These findings suggest that centralizing environmental governance reform shall receive extra credits for leading CER more effectively and reducing local protectionism.

The second chapter aims to investigate the effect of ESG disclosure on crash risk. Unlike the other chapters, we introduce an analytical model before empirical analysis. In the analytical model, we explicitly include two mediator factors: transparency and credibility of financial reports. The analytical model's solution reveals a non-monotonic relationship between ESG disclosure and crash risk. However, it doesn't give a specific function form (closed-form solution), so we then conduct the empirical analysis. We use Chinese A-share listed companies from 2006 to 2020 as a sample, and the result verifies the non-monotonic relationship between ESG disclosure and crash risk. As the ESG disclosure level increases, the ESG disclosure first reduces and then increases the crash risk. The findings coincide with the analytical model solution and are robust to different settings. The study amplifies the growing literature about ESG and its economic implications and supplements the knowledge of the determinants of stock price crash risk. The finding has a reference value for managers and regulators in China and other developing countries.

In the third chapter, we explore the relationship between ESG and corporate efficiency and whether corporate innovation impacts this relationship. The data used are Chinese A-share listed companies from 2006 to 2019. The results show a significant and positive relationship between the company's ESG performance and company efficiency. The three sub-pillars of ESG can also effectively improve corporate efficiency. Furthermore, the test results show that innovation plays a mediating role in the relationship between ESG and firm efficiency. We also found that innovation moderates this relationship. Specifically, when the company's innovation

level is low, the effect of ESG on corporate efficiency is more pronounced. Our research enriches the literature on ESG and company performance, the literature on factors affecting companies' total factor productivity (TFP), and that on the impact of innovation on companies. Our research results provide a reference value for the decision-making of company managers, investors, and governors.

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Finally, I am really grateful for the support of my family, especially my husband, Junjie.

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List of Abbreviations

ESG	**E**nvironmental, **S**ocial, and **G**overnance
CSR	**C**orporate **S**ocial **R**esponsibility
CER	**C**orporate **E**nvironment **R**esponsibility
SOECG	**S**tate-**O**wned **E**nterprise controlled by the **C**entral **G**overnment
SOELG	**S**tate-**O**wned **E**nterprise controlled by the **L**ocal **G**overnment
PE	**P**rivate **E**nterprise
NCSKEW	**N**egative **C**oefficient of **Skew**ness of firm-specific weekly returns
DUVOL	**D**own-to-**U**p **Vol**atility
TFP	**T**otal **F**actor **P**roductivity
FP	**F**irm **P**erformance
TFP_LP	**T**otal **F**actor **P**roductivity calculated using the **LP** method
TFP_OP	**T**otal **F**actor **P**roductivity calculated using the **OP** method

Introduction

Environmental problems can severely hinder economic development and social progress. With the growing public concern about strengthening environmental protection, sustainable economic and social development has gained more and more attention nowadays (Caiado et al., 2017). Given the fact that industrial pollution from enterprises is a big source of pollution, corporate sustainability is an essential part that should be seriously concerned (Lloret, 2016). Environmental, Social, and Governance (ESG) is an extension and enrichment of the concept of the green economy, corporate social responsibility, and responsible investment, which also refers to important standards for measuring the level of corporate sustainable development (Qiu and Yin, 2019).

It is critical to examine the relationship between ESG and firm performance. The original intention of the company's ESG activities is to protect the environment and give back to society. Companies will be reluctant to make ESG investments if ESG engagement will harm their interests. If ESG engagement is beneficial to the company's interests, then ESG engagement will be a win-win situation for the company, society, and the environment. This will also greatly encourage companies to engage in ESG activities. In this thesis, we study the relationship between corporate sustainability and firm value (Tobin's Q), stock price crash risk, and firm productivity. These three indicators can be a very comprehensive measure of the company's performance.

In the first chapter, we aim to examine the evolutionary effect of CER (the environmental dimension of ESG) on firm value over time when the institutional background is different. We use CER, which focuses on environmental performance,

since the environmental policy changes are directly related to CER while having little to do with the other two dimensions of ESG. Firm value refers to the company's ability to give satisfactory returns to corporate stakeholders (including shareholders, creditors, employees, etc.) to maximize profits and comply with laws and regulations. We use Tobin's Q to measure the value of the company because it reflects the expectations of the company's future profits. Firm value is important for firm managers and investors, as it provides a visual representation of the company's current and future profitability. It is the primary consideration when studying the impact of corporate sustainability on company performance.

In the second chapter, we explore the relationship between ESG disclosure and stock price crash risk in China. We use the ESG disclosure score rather than CER in this chapter. ESG score measures the disclosure level of ESG information and investors mainly use ESG disclosure reports to assist their investment decision-making. Therefore, ESG is more closely linked to crash risk. Here, we consider stock price crash risk. The likelihood of a company's stock price crash in the future is the third moment of the stock return distribution (conditional skewness) and depicts the transparency of company information and the stability of stock prices, which are crucial to investors' investment decisions and risk management.

Finally, we explore the impact of ESG on a company's total factor productivity (TFP) in the third chapter. TFP is a very important concept in the field of economic research, and it is often regarded as the "surplus" in total output that cannot be explained by input factors. TFP reflects the average output level of various input elements in the company's production process and is the company's overall efficiency in converting input into output.

Meanwhile, we have noticed that China began to carry out environmental reform in 2016, (including legislation, institutional framework reform, and enforcement), which changed China's institutional background. Therefore, we take 2016 as

a structural break, one before 2016 as a "steady period" and after 2016 as a "shaky period". When the company conducts CER engagement in a steady period, the benefit is less than the cost. During the shaky period, the benefits of CER will outweigh the costs, because companies with high CER suffer fewer environmental penalties, and the public pays more attention and recognition to CER performance. Therefore, it is necessary to consider this structural break in environmental policy in China when studying CER and firm value (Chapter one).

The structural break in environmental policy is not considered in ESG-crash risk and ESG-firm productivity relationships. ESG influences crash risk through two mechanisms. On the one hand, higher ESG means disclosing more information, thereby having a higher transparency level and reducing crash risk. On the other hand, higher ESG is more likely to be used as a tool by managers to pursue their own interests, thereby reducing credibility level and increasing crash risk. The structural break in environmental policy does not affect either. Likewise, ESG promotes firm productivity mainly through learning advanced technology and management experience in ESG-related activities, and reducing product and capital costs. Therefore, the structural break in environmental policy has little impact on this process.

Chapter 1

Is Corporate Environmental Responsibility More Valuable in the Shaky Period? The Moderating Effect of Ownership Type

1.1 Introduction

With growing environmental degradation, studies are increasingly focusing on corporate environmental responsibility (CER) engagements.[1] CER refers to a firm's willingness and ability to combine environmental considerations with its daily operations and management. The related literature is mainly devoted to the connotation, determinants, and consequences of CER (Porter and Kramer, 2006; Jo and Harjoto, 2012). In China, empirical studies have analyzed the determinants and consequences of CER. He and Chen (2009) discuss the drivers of CER among Chinese corporations and find the government and the social environment to be the most important in creating CER consciousness. Zeng et al. (2010) investigate the determinants and status of environmental information disclosure of Chinese listed companies. Du et al. (2014) examine religion's influence on polluting enterprises and find that Buddhism has a significantly positive correlation with CER. Wu et al. (2020) and Li et al. (2020) evaluate CER's impact on firm performance using different mediating factors.

Nonetheless, previous empirical studies do have some limitations. One limitation is that no attention has been paid to the evolution of CER's impact. That is, most studies implicitly assume a stable background regarding CER investments, which results in the same consequence from the same level of CER engagement. This assumption is reasonable for some developed countries, whose institutional and social backgrounds are relatively mature and stable (Holtbrügge and Dögl, 2012). However, it is impractical for countries such as China, where comprehensive environmental management reforms undertaken since 2016 have created a shaky institutional background. Nearly all listed enterprises have been investigated for a potential violation of environmental regulations, with some of them facing the prospect

[1] As an important part of corporate social responsibility (CSR), CER focuses on environmental responsibility and corporate sustainability. Thus, in this study, using CER instead of CSR can yield a more reliable conclusion.

of serious punishment (Jia and Chen, 2019). As a result, CER engagements have become a more important signal for the market than before as more CER engagements might be correlated with a reduced risk of punishment, a kind of "risk resistance indicator".

The other limitation is that there is no hypothesis that explains why CER's impact on firm value can be either negative or positive in the same country. For example, some researchers defending the trade-off hypothesis argue that CER could increase the operating costs of a company and, thereby, reduce the firm value, while others support the stakeholder theory, which indicates that CER has overwhelming benefits for building corporate reputation and enhancing competitive advantages (Dixon-Fowler et al., 2017). This study, however, hypothesizes that such debate can be attributed to local protectionism—unwarranted protection from local government to lower environmental protection requirements and create competitive advantages for local enterprises. We believe that when local protectionism is strong, the corporate competitiveness generated by greater CER engagements is trivial compared to lower environmental investment and that CER engagements actually damage firm value, and vice versa. Note that the environmental reforms undertaken in China since 2016 have strengthened environmental supervision[2] and weakened local protection. We, therefore, explore the role of CER's evolutionary impact on firm value while examining the role of local protectionism.

Thus, the purpose of this study is to examine CER's consequences over time—whether the impact of CER engagement on firm value changes when the institutional background is different. Equally important is investigating whether local protectionism can be considered an important potential factor by checking the evolution of CER's impact and the moderating effect of ownership type. In China, the ownership type of an enterprise affects the operation process of the enterprise. Compared with private enterprises, state-owned enterprises have little motivation to

[2]It is part of the centralization reform, which signifies greater local power to the central government and strengthens the central government's direct supervision powers.

chase profit and are more likely to comply with state policies. In addition, SOEs face greater public pressure. In this study, we divide all companies into three categories based on ownership type: firms controlled by the central government, firms controlled by local governments, and private firms. We investigate how the effects of CER differ with ownership type under the centralization trend in China.

Our study contributes to prior research in two ways. First, to our best knowledge, this is the first paper to investigate CER effectiveness under varying institutional circumstances. We use two subsample periods: a "steady period" representing a relatively steady institutional background from 2006 to 2015 and a "shaky period" representing a relatively shaky institutional background with environmental reform from 2016 to 2019. Second, we integrate environmental reform into an overall trend toward centralization in the Chinese administrative reform and provide a novel perspective to demonstrate how local protectionism influences CER's impact in the two periods and for different ownership types. Previous studies have pointed out an intrinsic connection between the centralization trend and environmental reform, but no study has explored the relationship between CER engagements and local protectionism (Zhang et al., 2018). Our subsample regression results strongly indicate weakened local protectionism during 2016-2019. Given the interest of firm managers and policymakers in the effect of CER engagement on firm value and constructing an encouraging institutional background for CER engagement, our results should be of great interest.

The remainder of this paper is arranged as follows. In Section 1.2, we discuss the varying institutional setups under which the study is conducted. Section 1.3 summarizes the literature and puts forward the hypotheses. Section 1.4 presents the sampling variables for empirical research and estimation methods. Section 1.5 is the empirical results, and Section 1.6 is the conclusion.

1.2 Institutional background

1.2.1 Environmental governance before 2016

The Chinese environmental governance system was set up in 1973, while initially concerns like deforestation and land overuse owing to poor agricultural practices were the main environmental problems. Although the central government was the dominant player in environmental governance on both legislation and enforcement until 1989, environmental protection had never been a priority compared to economic and social issues (He et al., 2012). Most environmental protection regulations and laws were drafted during 1989–2015, and local environmental protection bureaus were gradually established from the province level to the county level, thereby creating a comprehensive administration. Since 2012, the Chinese central government has assigned a high priority to environmental protection for local cadres (Wang, 2013).

Despite these institutional developments, rapid industrialization has resulted in greater environmental degradation (Sands et al., 2015). For example, the average PM2.5 (a kind of pollution particle smaller than 2.5 mm) concentration level in 170 Chinese cities in 2014 was around $61 \pm 20 \mu g/m^3$, $4 - 8$ times higher than the standard set by the World Health Organization for "good health," and only 9.5% of the cities monitored met the National Ambient Air Quality Standards (Wang et al., 2017).

Widespread lax environmental protection, or so-called local protectionism in environmental management, is to blame for weak protection (Lo, 2015; Van Rooij et al., 2017). On the one hand, the environmental regulatory framework had matured in a decentralized way that adopted a "divide and rule strategy" (Ran, 2013). That is, local environmental protection bureaus were empowered with sufficient discretion in return for no monetary support from the central government. This means that the Ministry of Environmental Protection (MEP) delegated its regulatory powers in exchange for a spending fee. On the other hand, under a dual leadership structure,

there are two higher authorities for local environmental protection bureaus—a high-level environmental protection branch (the vertical authority) and a local cadre (the horizontal authority). As fiscal and personnel powers were controlled mostly by local governments, local environmental protection bureaus responded more to these governments' desire for lax enforcement (Bai et al., 2004). This lax enforcement protected local enterprises and yielded the benefits of tax revenue, private benefits, as well as sound economic performance for the local government (Kostka, 2014). In line with the pollution haven hypothesis, lax environmental enforcement also attracted investments from manufacturing enterprises. This framework directly led to ineffectual supervision of enforcement by the MEP. Correspondingly, the MEP only guided provincial and sub-provincial regulatory administrations, which are often vague and aspirational (Yang, 2017). A former Minister of MEP, Zhou Shengxian, called his department one of the "four major embarrassing departments in the world" in 2013, admitting the distressing situation.

1.2.2 Environmental governance during 2016–2019

A crystal fact is that the main source of environmental degradation and resource consumption is industries (Przychodzen et al., 2018). To prevent factories and enterprises from bypassing regulations and laws, the central government launched comprehensive reforms in 2016. President Xi introduced the term "New Normal" to refer to the long-lasting changes from pursuing economic growth to more sustainable and balanced development. The reforms had a centralized pattern in three aspects: legislation, institutional framework reform, and enforcement (Li et al., 2019). For legislation, new and amended laws were enacted by the central committee, such as *Environmental Protection Law (revised)*, *Atmospheric Pollution Prevention and Control Law*, *Marine Environment Protection Law*, *Water Pollution Prevention and Control Law*, and *Law on the Prevention and Control of Environment Pollution Caused by Solid Wastes*. Similar regulations for the atmosphere, water, and soil protection were also issued

directly by the MEP.

Notably, the conventional "top-down" regulatory framework, where local cadres had the motivation and discretion to dominate environmental enforcement, was bypassed in the institutional restructuring process. The MEP now has more funds to support local environmental projects directly. Further, the Ministry of Ecology and Environment was established to replace the MEP in granting more responsibilities for environmental enforcement and supervision. There is tighter central control over local agents' fiscal powers and the salient deviation from the previously dominant performance-based governance system. That is, improved environmental enforcement has replaced robust GDP growth as one of the dominating factors for a local official's career promotion (Li et al., 2019). The central authority also encourages markets and NGOs to supervise the locally dominated environmental enforcement.

One landmark event during these reforms was an unprecedented Environmental Inspection led by the Central Government (EICG), initiated in 2016. The EICG focused on the re-evaluation of local governments' environmental enforcement and enterprises' illegalities. Under the direct supervision of central government officials, the EICG inspected all provinces in five batches over two years. Although the start date of inspections in the provinces varied for each batch, the inspection period was always one month. The Central Discipline Committee of the Communist Party of China, which is the enforcer of anti-corruption policies, was also involved to maximize the effectiveness of EICG. Since 2018, the second round of EICG was conducted to achieve consistent supervision. According to official reports, 1,527 people were taken into custody and 18,199 officials were publicly named for violating environmental laws.

In summary, it is widely recognized that local protectionism before 2016 led to lax environmental governance. The comprehensive reforms undertaken from 2016 to 2019, viewed as a part of a centralizing trend in administrative reform, have weakened this protectionism and overturned the lax enforcement, at least in the short

term.

1.3 Literature review and hypothesis development

1.3.1 Effects of CER on firm value in the steady period

CER is one of the key factors that align a firm's environmental protection engagement with firm value. However, there are long-standing debates on whether the benefits of CER activities exceed their costs in the short term. Many investigators agree with CER's overall positive contribution in helping to control costs, establish firm reputation, and earn credits from customers (Tantalo and Priem, 2016). The majority of these views are based on the stakeholder theory, which implies that CER contributes to firms' competitive advantage by helping them build a good reputation among stakeholders (Dixon-Fowler et al., 2017). Consequently, firm value can be enhanced by managing the core stakeholder relationship (Hamman et al., 2010).

In contrast, the trade-off hypothesis claims that CER activities could depreciate corporate financial performance despite apparent gains (Elsayed and Paton, 2005). This is because CER is viewed as a disadvantage that increases corporate costs and, thereby, reduces profitability (Liu et al., 2010). As CER activities consume the firm's core resources, they contribute directly to a relative disadvantage vis-a-vis competitors with a smaller CER engagement; hence, firms do not have the incentive to spend more on CER (Trumpp and Guenther, 2017). Islam and Deegan (2008) suggest that legislative pressure and accountability are the key elements that boost CER activities rather than mere earnestness. Darnall and Edwards Jr (2006) further list out factors that explain the reason of huger expenses while employing an environmental management system (one is CER implementation). The trade-off hypothesis has more appeal in developing markets, which focus more on enterprise profitability and are less sensitive to CER engagements.

Heberer and Schubert (2017) indicate that local governments could take advantage of their discretionary powers to evade environmental protection responsibilities

and defend local enterprises. In this case, the benefits of CER engagement are not evident because the market values enterprises' political connection more than CER engagement (Liu et al., 2018). Therefore, the cost of investing in CER will outweigh the benefits over the steady period. Based on the previous analyses, we support the trade-off hypothesis and propose Hypothesis 1.

Hypothesis 1: During the steady period (2006–2015), CER had a significantly negative impact on firm value, ceteris paribus.

1.3.2 Effects of CER on firm value in the shaky period

The mechanism of CER's effectiveness can be derived from ample theoretical research. It is widely agreed that changing CER's determinants from an inconsistent policy improves the stock market's response (Cots, 2011). CER is conceived as the accepted ideas of social relationships and norms that align enterprises' willingness with external factors (Frynas and Yamahaki, 2016). However, there is no consensus regarding how much time is needed for reform, and enterprises need much time and repeated attempts before successfully managing a new relationship. Due to temporary dysfunction, the stock market also adjusts its evaluation of CER's effectiveness (Mitchell et al., 1997). Mellahi et al. (2016) demonstrate that, in the formation of economic outcomes, nonmarket issues (political, social, or environmental) take effects through mediating mechanisms regarding organizational boundary spanning and external moderating mechanisms.

From the perspective of practical evidence, the other factor that explains the mechanism of CER's effectiveness is the increased business risk faced by enterprises since 2016. As discussed above, environmental enforcement was lax in China earlier. Many enterprises chose low-cost methods like bribery to evade environmental supervision. However, the environmental reforms since 2016 have overturned the

situation using multiple methods, including campaign-style inspection, stricter legislation, and institutional reform. For example, EICG was carried out by the central government from 2016 to 2018; the revised Marine Environment Protection Law was issued in 2017; the revised Water Pollution Prevention and Control Law was published in 2017; the Ministry of Environment was reorganized in 2018; an environmental lawsuit system was set up in 2018 and 2019; a Special Environmental Protection Fund was established in 2016. The central executive branch now takes more responsibilities in law enforcement while the local government's discretion is limited (Tian et al., 2019). One striking result is that enterprises that fail to comply with new regulations within a specified time face penalties and risk permanent closure as well (Zhang et al., 2018). Correspondingly, more CER engagements can be viewed as an appropriate "risk resistance indicator" that boosts the stock market's confidence.

In summary, based on the theoretical foundation and practical evidence, the Chinese environmental reform that purportedly threatens enterprise survival will cause CER's effectiveness to increase. Thus, we propose Hypothesis 2.

Hypothesis 2: During the shaky period (2016–2019), CER's impact on firm value significantly increased and was positive, ceteris paribus.

1.3.3 Distinctive effects of CER on firm value by ownership type

It is widely recognized that firm ownership type plays an important role in CSR's impact on firm value in China (Chen et al., 2009). Ownership type can be categorized into three groups: state-owned enterprises controlled by the central government (SOECG), state-owned enterprises controlled by the local government (SOELG), and private enterprises (PE) (Wang et al., 2008). State-owned enterprises (SOEs) including SOECGs and SOELGs are believed to be managed differently from PEs (Chen et al., 2009). For example, one SOE's managers are officials deputed by the government and therefore, their career prospects are closely related to the extent to which

their management executes instructions from their superiors.

One notable result of China's decentralized administrative structure is heterogeneous enforcement across localities and enterprises (Kostka and Nahm, 2017).[3] Heterogeneous enforcement refers to the fact that despite a uniform central management system, the ill-suited administrative structure eventually fails to enforce these laws and regulations coherently. China has a complex system of formal and informal divisions of authority between the central government and varied levels of regional and local governments (Lo and Fryxell, 2005). Heberer and Schubert (2017) demonstrate that local cadres still establish low-demand local regulations, regardless of strict national legislation, and take advantage of their discretionary powers to evade environmental protection responsibilities and defend local enterprises. Lax enforcement is particularly salient in the case of SOEs because of strong political connections. That is, SOELGs receive local protection because they are directly responsible for and are most politically connected with local authorities, and SOECGs receive more protection because their managers often have higher administrative rankings than the local heads (Wang, 2016). Therefore, engaging in CER activities will not result in external credits for SOEs as the stock market responds indifferently. Besides, according to the trade-off theory, the overweight cost from these engagements will result in enterprises spending the bare minimum on CER. Hence, CER effectiveness was negative particularly for SOECGs and SOELGs during the steady period (2006–2015).

From 2016, all enterprises could expect an increasingly positive CER effectiveness in the shaky period with weakened local protectionism as CER can be viewed as a "risk resistance indicator". However, CER effectiveness in SOEs could be greater because of "additional political score" (Van Rooij et al., 2017). Becoming an advocate

[3]The decentralized structure in the environmental executive branch is where the central government relinquishes most of its fiscal, administrative, and personnel powers to sub-national governments.

of central policies is believed to be an important signal of good risk resistance capability for SOEs and political achievement for their managers, as the Chinese government is used to promoting new policies by setting examples and commending them vigorously in the future. Private enterprises, on the other hand, rarely receive equivalent credit because of fewer political connections and are not fully trusted (Kung and Ma, 2018).

In brief, the cost of CER engagements shall surpass their benefits in the steady period particularly for SOEs, while they gain more from the combination of weakened local protectionism and unique benefits from political advocates. Therefore, we suggest Hypothesis 3.

Hypothesis 3: For SOELGs & SOECGs, the increased CER impact on firm value is larger than for PEs. That is, CER was more valuable for SOELGs & SOECGs during the shaky period.

1.4 Research design

1.4.1 Sample periods and data collection

The initial sample contains all A-listed firms[4] from 2006 to 2019. The data for CER calculation dates back earliest to 2006, and the COVID-19 pandemic occurred at the beginning of 2020, which may affect the results. China is suitable for our investigation of CER's evolutionary effectiveness for three reasons. First, China has been paying more attention to environmental information disclosure in recent years so that we can obtain suitable data related to corporate environmental responsibility (Li et al., 2020).[5] Second, China witnessed steady economic growth in the study period and provides a stable social environment beyond environmental management

[4]A-shares denote the publicly listed firms traded on Shenzhen and Shanghai Stock Exchanges. These stocks are traded in Renminbi (RMB), China's legal tender.

[5]The "Guidelines for Social Responsibility of Listed Companies" published in China in 2006 stipulates that Chinese listed firms should routinely assess their CSR performance in accordance with the guidelines.

reform.[6] Third, China has undergone comprehensive reforms in environmental governance from 2016 to 2019, which offers us the varying institutional circumstances needed for our study purpose. Finally, we split the study period into two distinct periods to capture the change in the institutional background.[7] The period from 2006 to 2015 is considered a relatively stable period regarding environmental management policy and enforcement, before the country started extensive environmental reforms in 2016. Therefore, a partition into two periods allows us to investigate CER effectiveness in different environments.

Our data set includes 1004 listed firms and 6232 observations. For the validity of the research, we exclude all special treatment (*ST/ST) firms[8] and firms that do not have our required data. Moreover, to avoid the influence of extreme values on the results, all continuous variables are winsorized at the 1st and 99th percentiles. The above data comes from the China Stock Market & Accounting Research Database (CSMAR), Chinese Research Data Services Platform (CNRDS), and Wind Database.

1.4.2 Measurement of variables

Corporate environmental responsibility

Content analysis was used to calculate CER by analyzing the related information disclosed in CSMAR and CNRDS. Based on Li et al. (2020), we evaluated CER on five dimensions: legal consciousness, low-carbon technology, eco-friendly production, social evaluation, and green management. Each dimension is measured by several indexes. The specific evaluation system is shown in Table 1.1. To maintain consistency in the direction of all indicators, firms that have not been penalized for environmental irregularities take the value of one; otherwise, they take the value of zero. Firms that are not discharging pollutants take a value of one; otherwise,

[6] See *Report on the Work of the Government 2019* (http://www.gov.cn/zhuanti/2019qglh/2019lhzfgzbg/index.htm).

[7] See the official schedule for comprehensive environmental reform, *Integrated Reform Plan for Promoting Ecological Progress* (http://www.caeisp.org.cn/zh-hans/integrated-reform-plan-promoting-ecological-progress).

[8] Those firms are at risk of being delisted.

they take a value of zero. For the rest of the indicators, if yes, we assign a value of one and zero otherwise. These indicators reflect the sampled firms' objective facts. We weighted all items equally to avoid subjectivity and obtain a reasonable calculation of CER for all selected firms. The score for each dimension is the aggregate of the scores of all indicators under each dimension, and the total CER score is the aggregate of the scores of five dimensions.

[Table 1.1]

Firm value

Firm value usually reveals the company's capability to provide satisfactory returns to all stakeholders (shareholders, creditors, managers, employees, etc.) under value-induced management and the rule of law. In this study, we use Tobin's Q to measure firm value. Tobin's Q is the ratio of a firm's market value to the replacement cost of its assets. It is widely used in accounting, economic and financial literature to measure the value of a firm (Mangena et al., 2012; Li et al., 2020). It is a good indicator for evaluating firm value since it can not only reflect the firm's past value but also consider its future performance expectations.[9]

Ownership structure of China's listed companies

According to the listed company equity documents from CSMAR, all Chinese listed firms can be divided into four types based on ownership structure: state-owned enterprises, private enterprises, foreign companies, and others. Further, state-owned enterprises are divided into three categories according to different hierarchies: city, province, and country. According to the distinct performance mechanisms of different ownership structure companies in different institutional backgrounds and consistent with the literature (Chen et al., 2009), we divide our sample enterprises

[9]Indicators like ROS, ROI, ROA, and ROE only reflect the firm's current profit rate, without reflecting the market's future expectation. Thus, the results using these indicators may have different results.

into three categories: SOECG, SOELG, and PE. We use dummy variables SOECG, SOELG, and PE to indicate the three kinds of enterprises.

Control variables

In addition to CER, many determinants that can potentially affect firm value are added into the estimation model as control variables. Referring to previous studies, we select the following control variables. Firm size (SIZE) measured as the natural logarithm of total assets is considered as an essential variable that affects firm value by economies of scale or scope (Stock et al., 2002). Other factors such as total leverage (LEVE; measured as operating leverage multiplied by financial leverage), debt ratio (DEBT; measured as the ratio of total debt divided by total assets), liquidity (CR; measured as current assets divided by current liabilities), fixed assets ratio (FA; measured as fixed assets divided by total assets), and firm age (AGE; measured as firm's listing age) are also included (Fosu et al., 2016; Kuzey and Uyar, 2017). The variables' description and measurements are shown in Table 1.2.

[Table 1.2]

Model construction

In this section, we exhibit the econometric model to explore the relationship between CER and firm value (Tobin's Q) in different periods. To test our hypotheses, we follow Mangena et al. (2012) to construct the following baseline regression model for all firms. In the model, the dummy variable "Period" is used to distinguish the steady and shaky periods.

Baseline model:

$$\begin{aligned}\text{Tobin's}Q_{i,t} =& \beta_0 + \beta_1 CER_{i,t} + \beta_2 CER_{i,t} \times \text{Period}_{i,t} + \beta_3 \text{Period}_{i,t} \\ &+ \beta_4 \text{Controls}_{i,t} + \text{Firm} + \text{Year} + \varepsilon_{i,t}\end{aligned} \tag{1.1}$$

where i indexes the firm, t indexes the year, and *Period* captures the different periods when the year of the observation is between 2016 to 2019. *Period* takes the value of 1, else 0. *Control* is a series of control variables that are expected to affect a company's value, such as size, debt ratio, total leverage, liquidity, fixed assets ratio, and firm listing age. *Firm* captures the firm-fixed effects. *Year* captures the time-fixed effects. We use the model controlling for the firm's fixed effects as the main model for this chapter, along with OLS regression as a comparison to enhance the robustness. In the OLS regression, we add *Industry* and *Province* to capture the industry-fixed and province-fixed effects. $\varepsilon_{i,t}$ is the error term. To determine if the impact of CER on firm value increased during the shaky period, our model contains the interaction term "CER*Period". To see how ownership type plays a moderating effect, we perform the previous regression on the ownership type subsamples.

1.5 Empirical results

1.5.1 Data description

Table 1.3 shows the descriptive statistics of all variables for the full period (2006–2019), the steady period (Period 0, 2006–2015), and the transitional period (Period 1, 2016–2019). The CER of the whole period ranges from 1 to 13 points, with an average score of 6.045. No firm has a CER level of zero, which signifies that all the A-listed firms in our study period provide CER information in their annual reports according to our measurement. The scores also show that the CER level of the sample firms has a wide range, with some firms obtaining a full score of 13 points. The mean of the CER level in the shaky period (6.151) is slightly higher than that of the steady period (5.956), which indicates a slightly increasing willingness in CER engagements during the shaky period. The mean firm value (Tobin's Q) in the shaky period (1.923) is slightly lower than in the steady period (2.216), because the stock market value decreased slightly after 2015. Regarding the control variables, the mean value of the natural logarithm of firm size is 23.128, the average value of the fixed assets ratio is

23.2%, the mean value of the current ratio is 1.98, the average debt-to-asset ratio is 47.8%, the mean total leverage is 2.447, and the average listing age is 12.135 years. These values are consistent with the previous studies (Kuzey and Uyar, 2017; Li et al., 2020).

[Table 1.3]

Figure 1.1 shows the trend of the variables over time. We can see from the figure that the average CER of the companies has an upward trend, but the increase is slight. Before 2016, the company's average value of Tobin's Q showed no obvious upward or downward trend although there were fluctuations. After 2016, it showed a slight decline. As for other control variables, AGE and company SIZE showed an obvious upward trend.

[Figure 1.1]

Table 1.4 is the correlation matrix, which exhibits the correlation between all the variables and suggests potential collinearity. After analyzing the correlation matrix and the variance inflation factor (VIF), we confirm that multicollinearity is not a concern for all the variables. We also observe that CER has a significantly negative impact on firm value.

[Table 1.4]

1.5.2 Baseline findings

We start our analysis by testing the impact of CER on firm value in the two periods. Table 1.5 reports the baseline results for the constructed models of the whole sample in the two periods. As shown in columns (1) - (4), the results are derived from two methods (ordinary least squares (OLS) and fixed-effects (FE)) and consider the existence of covariates' effects. Regardless of the method adopted (columns (1) and (2) vs columns (3) and (4)) or whether covariates are included (columns (1) and (3) vs columns (2) and (4)), the results are similar. Specifically, the CER coefficient is -0.032 and -0.038, respectively, and significant at the 1% level using both methods given the

involvement of covariates, indicating that every one-point increase in the CER score decreases Tobin's Q value by around 0.038 or around 1.5% in the steady period, all else being equal. This result shows that CER has a significantly negative impact on Tobin's Q from 2006–2015. These findings are consistent with some previous studies, such as Zeng et al. (2010) and Shen et al. (2019), which also found a negative relationship between CER and firm value, while different from the findings of Plumlee et al. (2015), which showed a positive relationship between the two variables. The results strongly support Hypothesis 1. On the other hand, the CER*Period coefficient is 0.065 and 0.062, respectively, and significant at the 1% level using both methods given the involvement of covariates, showing the significantly increased CER effectiveness in the shaky period. We present the "Total effects of CER and CER*Period" at the bottom of the table, which indicates that every one-point increase in the CER score increases approximately 0.024 of Tobin's Q value in the shaky period, all else equal. This result confirms that CER has a positive impact on Tobin's Q during 2016–2019, which strongly supports Hypothesis 2. With respect to the effect of covariates, we find that firm size (SIZE) is negatively related to Tobin's Q, which implies that bigger firms are relatively inefficient. Furthermore, the fixed assets ratio, total leverage, and debt ratio are significantly negatively correlated with Tobin's Q. We also find that the current ratio is significantly positively correlated with firm value. These coefficients of control variables are consistent with those of previous studies (Li et al., 2020).

[Table 1.5]

We then test the moderating effect of ownership type between CER and firm value. Table 1.6 reports the results from the subsample regression of the two periods. Columns (1), (2), and (3) show the results from the OLS method, while columns (4), (5), and (6) indicate those from the FE model. The "Empirical P-value" at the bottom of the table is used to test the significance of the difference in the "CER*Period" coefficients compared to that of the PE subsample. Following Lian et al. (2010), we

obtain it using Fisher's Permutation test. First, focusing on the CER coefficient, we find that CER had a more negative impact on firm value for SOECGs and SOELGs than PEs in the steady period in both models. This is consistent with our hypothesis that SOECGs and SOELGs receive stronger local protection because of their closer connections to the local governments. When local protection is strong, corporate competitiveness generated by greater CER engagements would be insignificant compared to the lower environmental investment; thus, CER engagements are a disadvantage for firm value since the corresponding added cost may exceed the value of any added benefit and vice versa. PEs benefited less from local protectionism than the other types during the steady period and therefore gained more "compensation" from CER engagements. From columns (4) and (5), we also noted that CER affects SOECGs more negatively than SOELGs in the steady period. This is because SOECGs receive more protection since their managers often have higher administrative rankings than the local heads (Wang, 2016).

Second, focusing on the interaction term CER*Period, both methods strongly support that CER's positive impact increased the most for SOECGs and the least for PEs during the shaky period in both models. The empirical P-values are less than 0.1, indicating that the coefficient difference between groups is significant at the 10% significance level. When comparing model (1) with the model (3), CER's impact increases over 30% more for SOECGs than for PEs. This finding further supports our hypothesis that following the environmental reforms and reduced local protection during the shaky period, SOECGs, which suffered the most from reduced local protection, gained the most competitive advantage from CER engagements. These competitive advantages from CER promote firm value in two ways: first, as a "risk resistance indicator" to credit the enterprise's capacity for surviving and running smoothly during the shaky period, and second, as an "additional political score" to credit the enterprise's capacity for advocating new policies. These findings, therefore, strongly support Hypothesis 3 and indicate the involvement of local

protectionism.

[Table 1.6]

1.5.3 Endogeneity concerns

The issues like simultaneity and reverse causality may exist in the relationship between CER and firm value. For example, Tobin's Q can affect CER engagement since a firm with a higher Tobin's Q may have a higher capability to conduct CER engagement. To eliminate potential endogeneity caused by simultaneity and reverse causality, we adopt lagged explanatory variables instead of contemporaneous variables; the results are reported in Table 1.7. In columns (1) and (2), we use OLS estimation with industry-fixed effects, province-fixed effects, and year-fixed effects. In columns (3) and (4), we use the FE model for estimation with firm-fixed effects and year-fixed effects. We include control variables in columns (2) and (4). We can see from the table that for L.CER (lagged CER) and L.CER*Period (lagged CER*Period), the coefficients are similar to those of Table 1.5. The same implications hold: CER had a significantly negative impact on Tobin's Q from 2006–2015 (which strongly supports Hypothesis 1) and had a significantly positive incremental effect on Tobin's Q during 2016–2019 (which strongly supports Hypothesis 2).

[Table 1.7]

We also employ the instrumental variables method to alleviate the endogenous concerns of omitting correlated variables, using the average CER of all other firms in the same industry as the instrumental variable.[10] This instrumental variable needs to satisfy both relevance and exogenous restrictions: on the one hand, the average CER of all other firms in the same industry is usually related to the specific firm's CER; on the other hand, the average CER of all other firms in the same industry cannot affect its firm value. We have performed relevant tests to show that the instrumental variables are appropriate. For the endogeneity test: The P values of the Durbin-Wu-Hausman test were zero, rejecting the null hypothesis that "CER" and "CER*Period"

[10]The IV estimation method used in this study is two-stage least squares (2SLS) regression

are exogenous variables. For the weak instrumental variable test: The first-stage F values are around 48 and 701, indicating that there is a significant correlation between instrumental variables and endogenous explanatory variables.[11] The IV regression results are displayed in Table 1.8. Columns 1-3 are IV regressions without control variables, and columns 4-6 are IV regressions with control variables. For the first stage, we consider two endogenous variables, namely, CER and CER*Period. For this reason, two IVs, IV_CER and IV_CER*Period are used. Here, IV_CER is the average CER of all other firms in the same industry. For both the CER equation and CER*Period equation, we have used both IV_CER and IV_CER*Period. We control "Control" for both equations at the first stage. The control variables used in both equations are the same and also the same as those used in the second stage. From Table 1.8, we can see that CER's impact on firm value during the steady period and its incremental impact during the shaky period are consistent with our baseline model. That is, the coefficients of CER are significantly negative (-0.587 and -0.300), and the coefficients of the CER*Period are significantly positive (0.204 and 0.158) in the regression results in the second stage.

[Table 1.8]

1.5.4 Robustness check

The robustness of the results is checked through several further analyses, which support our theoretical framework and propositions. First, we run separate OLS and FE model regressions for the steady period (2006–2015) and the shaky period (2016–2019). The subsample results are shown in Table 1.9, where columns (1) and (2) indicate the OLS regression results and columns (3) and (4) indicate the FE regression results. Using simple comparison, we find that the OLS results are consistent with the previous baseline findings; the impact of CER on firm value is significantly negative during the steady period, while it is significantly positive during the shaky period and is significant at the 5% level. Although the FE model regression results

[11] Both F-values have a P-value of zero.

are not significant, they show a predicted sign. Therefore, the regression results of the subsample support our findings.

[Table 1.9]

Second, we observe that the EICG was conducted during the environmental reforms. As Table 1.10 implies, EICG was conducted in batches, and there were natural control and treated groups in each batch. Therefore, we can use the difference-in-difference (DID) method to examine the average treatment effect of EICG and consider receiving treatment as a substitute for experiencing a shaky period for enterprises.

Following Zhang et al. (2021), we construct a DID regression model to examine the increased CER impact on firm value:

$$\begin{aligned} \text{Tobin's } Q_{i,t} = \beta_0 + \beta_1 CER_{i,t} + \beta_2 CER_{i,t} \times \text{ Inspect }_{i,t} + \beta_3 \text{ Inspect }_{i,t} \\ + \beta_4 \text{ Controls }_{i,t} + \text{Firm} + \text{Year} + \varepsilon_{i,t} \end{aligned} \tag{1.2}$$

Here, Inspect is equal to one if firm i is under or has finished inspection in year t, and zero otherwise. CER*Inspect shows the incremental CER impact after the EICG. During the period of EICG enforcement, all firms are finally affected by the inspection, although in different orders. Thus, in this DID setting, the treatment group contains firms that have already been inspected, and the control group contains firms that have not been inspected yet. Here, we use "Inspect" to capture the difference.[12] We can interpret the results like CER impacts differently on Tobin's Q and "Inspect" mitigates the negative impact. The results from the DID method are compared with the baseline results to assess robustness. From the results shown in Table 1.11, the coefficients of CER, CER*Inspect, and "Total effects of CER and

[12] All provinces and firms are affected by EICG and the EICG is conducted in five batches (ABCDE, respectively) in different time orders. For example, when firms in batch A are under inspection, firms in BCDE now have not been inspected, the treatment group contains firms in batch A and the control group contains firms in batch BCDE. When firms in batch B are under inspection, then the treatment group includes firms in batch AB and the control group includes firms in batch CDE. In this case, a simple DID (with constant treatment group and control group is not fit). thus a time-varying DID is used here.

CER*Inspect" are strongly consistent with the baseline findings in Table 1.5 regardless of whether there is an involvement of covariates. The four coefficients of CER in the first row show that the impact of CER on firm value is significantly negative in the steady period. The four coefficients of "CER*Inspect" in the second row show that the incremental CER's impact on firm value is significantly positive in the shaky period. Thus, this test supports the validity of our findings.

[Tables 1.10 & 1.11]

The DID design requires the parallel-trend assumption, which is used to verify that there is no significant trend difference between the treated group and the control group before implementing the policy. According to Zhang et al. (2021) and Fang and Wu (2020), we use the following equation to explore the pre-EICG trend of the two groups.

$$\begin{aligned}\text{Tobin's } Q_{i,t} = {} & \beta_0 + \beta_1 CER_{i,t} + \beta_2 CER_{i,t} \times \text{ Inspect }_{i,t}^{-6} \\ & + \beta_3 \text{ CER }_{i,t} \times \text{ Inspect }_{i,t}^{-5} + \beta_4 \text{ CER } R_{i,t} \times \text{ Inspect }_{i,t}^{-4} \\ & + \beta_5 \text{ CER }_{i,t} \times \text{ Inspect }_{i,t}^{-3} + \beta_6 CER_{i,t} \times \text{ Inspect }_{i,t}^{-2} \\ & + \beta_7 \text{ CER }_{i,t} \times \text{ Inspect }_{i,t}^{-1} + \beta_8 CER_{i,t} \times \text{ Inspect }_{i,t}^{0} \\ & + \beta_9 \text{ CER } R_{i,t} \times \text{ Inspect }_{i,t}^{1} + \beta_{10} \text{ CER }_{i,t} \times \text{ Inspect }_{i,t}^{2} \\ & + \beta_{11} CER_{i,t} \times \text{ Inspect }_{i,t}^{3} + \beta_{12} \text{ Controls }_{i,t} + \text{Firm} \\ & + \text{Year} + \varepsilon_{i,t}\end{aligned} \tag{1.3}$$

Where $\text{Inspect}_{i,t}^{-j}$ equals one for region i in jth year before the EICG enforcement, $\text{Inspect}_{i,t}^{+j}$ equals one for region i in jth year after the EICG enforcement, $\text{Inspect}_{i,t}^{0}$ equals one for region i in the year under the EICG enforcement, otherwise, those variables equal to zero. $\text{CER}_{i,t} \times \text{Inspect}_{i,t}^{-j}$ captures the differences of CER effectiveness between the treated group and control group in jth year before the policy.

We present the result of the parallel-trend test in Table 1.12. For brevity, we have not presented the coefficients of control variables. Furthermore, Figure 1.2 plots the estimation coefficients, shown as the circles in the middle of the dashed lines, and

their 95% confidence intervals, shown as the dashed lines. As shown in the table and figure, all coefficients of $\text{Inspect}_{i,t}^{-j}$ are not significant, while the coefficients of $\text{Inspect}_{i,t}^{0}$ and $\text{Inspect}_{i,t}^{+j}$ are positive and significant. Hence, the parallel-trend assumption is verified.

[Table 1.12]

[Figure 1.2]

Third, we conduct the placebo test to exclude the effect of time-changing factors. The argument is that, given the assumption that the environmental reforms began in another year rather than in 2016, if there exists any significant non-zero coefficient of CER*Period (indicating the incremental impact of CER on firm value) before 2016 or any insignificant close-to-zero coefficient of CER*Period after 2016, then our preceding time division will lose its statistical validity. We use Period14 to represent the assumed beginning of the shaky period from 2014; thus, CER*Period14 captures the incremental impact of CER on firm value in the assumed shaky period. The other interaction terms, such as CER*Period15, CER*Period17, and CER*Period18 have similar meanings. The placebo results are shown in Table 1.13. All four columns' results clear our concerns, as coefficients of CER*Period14 and CER*Period15 are both close to zero, and coefficients of CER*Period, CER*Period17, and CER*Period18, are all significantly non-zero.

Furthermore, the coefficients of CER*Period across the three ownership type groups after 2016 also support our findings from Table 1.6. That is, the incremental CER impact is highest for SOECGs and least for PEs. One interesting result is that if we split the period later (2017 or 2018), the difference in CER effectiveness is more salient as SOECGs benefit increasingly more from CER engagements than others. This pattern might reflect the theoretical proposition that since the shaky period is composed of an integration of many environmental reforms rather than just a sole campaign-style EICG in 2016, we should expect a shift from the shaky period to another steady period with normalized stringent supervision in the future.

[Table 1.13]

Fourth, we use interaction terms of three variables to investigate the moderating effect of SOE on the incremental effect of CER in the shaky period (CER*Period*SOE) or after the inspection (CER*Inspect*SOE). The regression equation is as follows:

$$\begin{aligned}\text{Tobin's } Q_{i,t} = {} & \beta_0 + \beta_1 CER_{i,t} + \beta_2 CER_{i,t} \times \text{ Period }_{i,t} + \beta_3 CER_{i,t} \times \text{ Period}_{i,t} \times SOE_{i,t} \\ & + \beta_4 \text{ Period }_{i,t} + \beta_5 \text{ Controls }_{i,t} + \text{Year} + \text{Firm} + \varepsilon_{i,t}\end{aligned} \tag{1.4}$$

$$\begin{aligned}\text{Tobin's } Q_{i,t} = {} & \beta_0 + \beta_1 CER_{i,t} + \beta_2 CER_{i,t} \times \text{ Inspect }_{i,t} + \beta_3 CER_{i,t} \times \text{ Inspect}_{i,t} \times SOE_{i,t} \\ & + \beta_4 \text{ Inspect }_{i,t} + \beta_5 \text{ Controls }_{i,t} + \text{Year} + \text{Firm} + \varepsilon_{i,t}\end{aligned} \tag{1.5}$$

The results of the two fixed effect models are shown in Table 1.14. We use "P" to represent Period or Inspect. In Table 1.14, we can see that the coefficients of interaction terms "CER*Period*SOE" and "CER*Inspect*SOE" are both significantly positive. This indicates that the CER incremental effect of SOEs is significantly larger than that of private firms. This result is consistent with the results in Table 1.6 and in line with hypothesis 3.

[Table 1.14]

Finally, changes in the impact of CER on company value in the two periods may be affected by investor sentiment[13] in the stock market during the two periods. Therefore, we add investor sentiment as a control variable to control for the result bias caused by this factor. The measurement method of investor sentiment is provided in the appendix. Table 1.15 and Table 1.16 show the results after adding investor sentiment. It can be seen that after controlling for investor sentiment, the results are consistent with our baseline findings.

[Tables 1.15 & 1.16]

[13]Investor sentiment refers to the systematic deviation of investors' expectations for the future (Zhang and Zhu, 2014).

1.6 Conclusion

The government and the public have been paying increasing attention to environmental degradation in recent years and demanding greater environmental accountability and disclosure from enterprises. CER, which measures the willingness and investment of enterprises for environmental protection, thus assumes importance. It is explicitly demonstrated that CER has an impact on firm value, but whether this impact is positive or negative is still debatable. As many studies[14] in China yield mixed results, we believe strong local protectionism could be the potential reason. Notice that the environmental reforms undertaken from 2016 have strengthened environmental supervision and weakened local protection. CER's impact in two separate time periods (before and after 2016) is considered in our study to test the evolution of CER's impact. The moderating role of ownership is also studied to better reveal the existence of local protectionism.

In this study, we investigate the impact of CER on firm value using data of Chinese A-listed firms from 2006–2019. We first examine whether there is a significant difference in CER's effectiveness on firm value between the steady period and the shaky period. Then, we investigate the moderating role of firm ownership type on this relationship in the two periods to check local protectionism's role. Our results show that, first, CER negatively affects firm value in the steady period but positively affects it in the transitory period. Second, the firm's ownership type moderates the impact of CER on firm value. Third, during the environmental reforms, SOECGs increased the most CER effectiveness and PEs increased the least of it. In other words, enterprises that previously received more local protection showed larger increments in CER effectiveness.

This study makes two main contributions. First, to the best of our knowledge, it is the first to investigate CER's evolutionary effectiveness under varying institutional circumstances–that is, whether there is a robust change in the impact of CER

[14] See Li et al. (2020) and Xu et al. (2021) as examples.

on the firm value before and after the environmental reforms. The results show that the effect of CER on firm value is not homogenous across different institutional backgrounds and firm types, and provide strong evidence of the involvement of local protectionism in the relationship between CER and firm value. Second, we reasonably interpret changes in the strength of local protectionism as an explanation for CER's evolutionary effectiveness. Our results demonstrate the role of weakened local protectionism after 2016 and help us to view the environmental reforms from a new perspective–namely, as a part of the larger Chinese administrative reforms to combat decentralization.

Our findings are very relevant to firm managers, investors, and policymakers. When deciding on CER investment, managers should comprehensively consider the company's characteristics and institutional background to optimize their results. They should consider greater CER engagements and information disclosure when anticipating strict environmental enforcement and weak local protection in a few years. For investors, keeping a close eye on policies and changes in public awareness is necessary when reasonably estimating firm value. Our results show that throughout the environmental reform period, greater CER engagements benefited SOECGs. Therefore, investors should also be more attentive to CER. Policymakers should try to ensure strict and effective implementation of environmental policies and laws. Our results show that to make environmental policies truly effective, policymakers need to combat local protectionism. Moreover, when environmental protection policies are strictly implemented, CER's positive effect is more prominent. This will undoubtedly lead companies to more environmental protection investments and promote sustainable development.

Tables

TABLE 1.1: CER evaluation system

Dimensions	Indicators
Legal consciousness	1. Whether to pursue the Global Reporting Initiative Sustainable Reporting Guidelines 2. Whether to reveal the environmental and sustainable development information 3. Whether environmental penalties are imposed
Low carbon technology	1. Whether to conserve energy 2. Whether to exploit or utilize environmentally friendly technologies
Eco-friendly production	1. Whether to employ a circular economy 2. Whether to conduct green production 3. Whether to discharge pollution
Social evaluation	1. Whether received an environmental approbation 2. Whether to possess environmental benefits
Green management	1. Whether to have a third-party authentication 2. Whether to possess an ISO 14001 certification 3. Whether to adopt green office

Note: This CER evaluation system is directly referred to Li et al. (2020).

TABLE 1.2: Variable description

Variables	Description
Tobin's Q	Market value divided by total assets
CER	Measured by CER evaluation system
Period	Measured as 1 if in the shaky period, otherwise 0
Inspect	Measured as 1 if firm i in year t is under inspection, otherwise 0
SIZE	The natural logarithm of total assets
LEVE	Operating leverage multiplied by financial leverage
DEBT	The total debt divided by total assets
CR	The current assets divided by current liabilities
FA	Fixed assets divided by total assets
AGE	The firm listing age
SOECG	Measured as 1 if firm i is a state-owned enterprise affiliated by the central government, otherwise 0
SOELG	Measured as 1 if firm i is a state-owned enterprise affiliated by the local government, otherwise 0
PE	Measured as 1 if firm i is a private enterprise, otherwise 0
Province fixed effect	Province dummies to control for common features at province level
Industry fixed effect	Industry dummies to control for common features at the industrial level
Year fixed effect	Time dummies to control for common macroeconomic effect
Firm fixed effect	Control for common features at firm level

TABLE 1.3: Descriptive statistics

Sample	Variable	N	Mean	SD	Min	P25	Median	P75	Max
Whole	Tobin's Q	6232	2.082	1.407	0.818	1.163	1.591	2.413	8.322
	CER	6232	6.045	1.898	1.000	5.000	6.000	7.000	13.000
	FA	6232	0.232	0.184	0.002	0.083	0.185	0.341	0.753
	CR	6232	1.980	1.887	0.252	1.049	1.451	2.136	12.984
	DEBT	6232	0.478	0.197	0.064	0.329	0.489	0.630	0.860
	LEVE	6232	2.447	2.935	0.966	1.229	1.530	2.246	21.346
	SIZE	6232	23.128	1.482	18.650	22.050	22.988	24.041	28.509
	AGE	6232	12.135	6.696	0.000	7.000	12.000	17.000	28.000
Period=0	Tobin's Q	3386	2.216	1.476	0.818	1.241	1.703	2.587	8.322
	CER	3386	5.956	1.774	2.000	5.000	6.000	7.000	12.000
	FA	3386	0.241	0.185	0.002	0.093	0.194	0.356	0.753
	CR	3386	2.045	2.078	0.252	1.044	1.437	2.142	12.984
	DEBT	3386	0.481	0.202	0.064	0.330	0.493	0.640	0.860
	LEVE	3386	2.553	3.250	0.966	1.208	1.509	2.251	21.346
	SIZE	3386	22.899	1.464	19.276	21.872	22.775	23.770	28.509
	AGE	3386	10.597	5.922	0.000	5.000	11.000	15.000	25.000
Period=1	Tobin's Q	2846	1.923	1.303	0.818	1.079	1.475	2.237	8.322
	CER	2846	6.151	2.032	1.000	5.000	6.000	8.000	13.000
	FA	2846	0.221	0.181	0.002	0.076	0.176	0.329	0.753
	CR	2846	1.902	1.626	0.252	1.056	1.466	2.121	12.984
	DEBT	2846	0.474	0.190	0.064	0.328	0.483	0.618	0.860
	LEVE	2846	2.321	2.503	0.966	1.245	1.554	2.237	21.346
	SIZE	2846	23.399	1.457	18.650	22.342	23.301	24.288	28.509
	AGE	2846	13.964	7.093	0.000	8.000	15.000	20.000	28.000

Note: Our sample contains all listed firms in the Chinese A-share market after dropping special treatment (ST) firms and observations with missing values. The whole period of the sample is 2006-2019. "Period =0" refers to subsamples in a steady period (2006-2015), and "Period =1" refers to subsamples in a shaky period (2016-2019). P25 refers to the 25th percentile and P75 refers to the 75th percentile. The total numbers of firms and observations are 1004 and 6232, respectively.

TABLE 1.4: Correlation matrix

	Tobin's Q	CER	Period	FA	CR	DEBT	LEVE	SIZE	AGE
Tobin's Q	1								
CER	-0.187***	1							
Period	-0.104***	0.051***	1						
FA	-0.172***	0.097***	-0.053***	1					
CR	0.390***	-0.167***	-0.038***	-0.267***	1				
DEBT	-0.455***	0.171***	-0.019	-0.003	-0.630***	1			
LEVE	-0.168***	0.024*	-0.039***	0.309***	-0.197***	0.234***	1		
SIZE	-0.473***	0.373***	0.168***	0.074***	-0.394***	0.565***	0.090***	1	
AGE	-0.271***	0.070***	0.250***	-0.029**	-0.194***	0.229***	0.067***	0.281***	1

Note: This table reports the correlation coefficients of each variable in our main regression. All correlation coefficients are below 0.8 which indicates there is no significant multi-collinearity problem.

TABLE 1.5: The relation between CER and firm value in two periods

	(1) OLS	(2) OLS	(3) FE	(4) FE
CER	-0.108***	-0.032***	-0.045***	-0.038***
	(-9.71)	(-3.14)	(-3.68)	(-3.22)
CER*Period	0.067***	0.065***	0.059***	0.062***
	(4.52)	(4.95)	(4.19)	(4.61)
Period	-0.504	-0.087	-0.992***	-3.343***
	(-1.52)	(-0.25)	(-3.09)	(-7.48)
FA		-0.676***		-0.268
		(-5.70)		(-1.05)
CR		0.055***		-0.034
		(3.57)		(-1.54)
DEBT		-0.981***		-0.170
		(-7.92)		(-0.68)
LEVE		-0.025***		-0.031***
		(-6.14)		(-7.23)
SIZE		-0.227***		-0.577***
		(-16.26)		(-8.01)
AGE		-0.029***		0.272***
		(-11.47)		(11.07)
Constant	3.870***	8.795***	—	—
	(9.47)	(17.33)	—	—
Industry	Yes	Yes	No	No
Province	Yes	Yes	No	No
Year	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	6232	6232	6232	6232
adj. R^2	0.372	0.496	0.270	0.319
F	32.855	51.212	129.851	123.161
*Total effects of CER and CER*Period (using Wald test)*				
	-0.041***	0.033***	0.014	0.024**

Note: This table reports the OLS and fixed-effect (FE) regression results of research in which the dependent variable is Tobin' Q. Our primary concern is whether the impact of CER on firm value increased in shaky period (Period =1 refers to the shaky period, 0 otherwise). The coefficient of CER captures the relationship between CER and firm value in a steady period. The interaction term CER*Period captures the incremental impact of CER in a shaky period. We report the OLS regression results with industry, province, and year fixed effects included in columns (1) and (2), and FE regression results with firm and year fixed effects included in columns (3) and (4). Besides, in columns (3) and (4), the control variables are added while there are no control variables in columns (1) and (2). The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.6: The moderating effect of ownership type

	(1) OLS SOECG	(2) OLS SOELG	(3) OLS PE	(4) FE SOECG	(5) FE SOELG	(6) FE PE
CER	-0.027*	-0.033**	-0.018	-0.064***	-0.026	-0.025
	(-1.70)	(-2.49)	(-0.87)	(-3.37)	(-1.60)	(-1.06)
CER*Period	0.072***	0.068***	0.055**	0.078***	0.054***	0.049*
	(3.36)	(4.06)	(2.08)	(3.24)	(2.75)	(1.95)
Period	1.479***	-0.563	0.400	-3.157***	-2.236***	-4.461***
	(4.63)	(-1.44)	(0.94)	(-3.24)	(-3.80)	(-6.13)
FA	-0.126	-0.777***	-0.696**	0.477	0.277	-1.244*
	(-0.55)	(-5.67)	(-2.47)	(1.33)	(1.09)	(-1.95)
CR	0.118***	-0.026	0.033	0.058	-0.014	-0.070**
	(2.96)	(-1.06)	(1.43)	(1.35)	(-0.35)	(-2.43)
DEBT	-0.716***	-0.791***	-1.242***	-0.211	0.339	-0.311
	(-2.84)	(-5.09)	(-4.67)	(-0.57)	(1.00)	(-0.63)
LEVE	-0.023***	-0.026***	-0.045***	-0.031***	-0.022***	-0.046***
	(-3.08)	(-5.83)	(-3.91)	(-4.20)	(-4.15)	(-4.13)
SIZE	-0.295***	-0.214***	-0.245***	-0.601***	-0.319***	-0.662***
	(-12.63)	(-9.69)	(-7.66)	(-5.27)	(-3.97)	(-4.95)
AGE	-0.024***	-0.010**	-0.030***	0.188***	0.147***	0.412***
	(-4.63)	(-2.23)	(-5.98)	(5.00)	(4.96)	(8.43)
Constant	7.094***	7.288***	8.793***	—	—	—
	(11.87)	(10.08)	(11.92)	—	—	—
Industry	Yes	Yes	Yes	No	No	No
Province	Yes	Yes	Yes	No	No	No
Year	Yes	Yes	Yes	Yes	Yes	Yes
Firm	No	No	No	Yes	Yes	Yes
N	1518	2242	2472	1518	2242	2472
adj. R^2	0.603	0.519	0.477	0.330	0.306	0.375
F	26.005	24.966	20.794	32.672	42.801	59.827
Empirical p-value (using Fisher's Permutation test)						
	0.075*	0.089*		0.043**	0.082*	

Note: This table reports the OLS and fixed-effect (FE) regression results of ownership type subsamples in which the dependent variable is Tobin's Q. We report the OLS results with industry, province, and year fixed effects included in columns (1), (2) and (3), FE regression results with firm and year fixed effects included in columns (4), (5) and (6). The "Empirical P-value" is used to test the significance of the difference in the "CER*Period" coefficients compared to that of the PE subsample. It is obtained by 500 times of self-sampling (Bootstrap). The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.7: Regression results with lag endogenous variables

	(1) OLS	(2) OLS	(3) FE	(4) FE
L.CER	-0.099***	-0.028**	-0.034***	-0.025**
	(-8.32)	(-2.56)	(-2.61)	(-2.02)
L.CER*Period	0.058***	0.054***	0.056***	0.052***
	(3.72)	(3.86)	(3.64)	(3.49)
Period	-0.590	-0.245	-1.489***	-3.296***
	(-1.03)	(-0.46)	(-4.40)	(-7.09)
L.FA		-0.554***		-0.152
		(-4.52)		(-0.59)
L.CR		0.057***		-0.030
		(3.56)		(-1.31)
L.DEBT		-0.875***		0.302
		(-6.95)		(1.23)
L.LEVE		-0.009		-0.014**
		(-1.53)		(-2.31)
L.SIZE		-0.213***		-0.563***
		(-15.07)		(-7.32)
AGE		-0.024***		0.229***
		(-8.54)		(9.45)
Constant	4.085***	8.674***	—	—
	(6.25)	(12.64)	—	—
Industry	Yes	Yes	No	No
Province	Yes	Yes	No	No
Year	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	4826	4826	4826	4826
adj. R^2	0.393	0.504	0.259	0.297
F	28.862	42.491	99.512	88.714

Note: We lag some explanatory variables by one year and perform the OLS and FE regression to alleviate the endogenous problem caused by simultaneity or reverse causality. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.8: IV regression results

	(1)	(2)	(3)	(4)	(5)	(6)
	First	First	Second	First	First	Second
Dep. Var.	(CER)	(CER* Period)	(Tobin's Q)	(CER)	(CER* Period)	(Tobin's Q)
IV_CER	0.901***	-0.008		0.666***	-0.132***	
	(19.05)	(-0.84)		(13.94)	(-8.70)	
IV_(CER* Period)	0.150**	1.068***		0.229***	1.113***	
	(2.22)	(21.54)		(3.50)	(22.85)	
CER_HAT			-0.587***			-0.300***
			(-11.64)			(-5.89)
(CER*Period)_HAT			0.204***			0.158***
			(3.29)			(2.96)
Period	0.865	-0.195	-0.496	-0.271	-0.849***	-0.288
	(1.60)	(-0.62)	(-1.00)	(-0.50)	(-2.66)	(-0.70)
Controls	No	No	No	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	6232	6232	6232	6232	6232	6232
F	33.888	749.391		47.866	701.289	

Note: To alleviate the endogenous concerns on omitted correlated variables, we conduct the instrumental variables method, we use the average CER of all other firms in the same industry as the instrumental variable. We report the results of the instrumental variables approach in this table, columns (1) and (2) without control variables while columns (3) and (4) with control variables. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$..

TABLE 1.9: The relationship between CER and firm value in period subsamples

	(1) OLS Period=0	(2) OLS Period=1	(3) FE Period=0	(4) FE Period=1
CER	-0.026**	0.025**	-0.005	0.001
	(-2.43)	(2.37)	(-0.34)	(0.11)
FA	-0.559***	-0.697***	-0.216	0.097
	(-3.34)	(-4.11)	(-0.55)	(0.26)
CR	0.013	0.144***	-0.068**	0.024
	(0.71)	(5.42)	(-2.43)	(0.63)
DEBT	-1.331***	-0.449**	0.226	-1.110**
	(-7.95)	(-2.44)	(0.65)	(-2.43)
LEVE	-0.024***	-0.022***	-0.038***	-0.020***
	(-4.09)	(-3.74)	(-5.42)	(-3.13)
SIZE	-0.258***	-0.189***	-0.796***	-0.020
	(-13.68)	(-8.98)	(-7.23)	(-0.14)
AGE	-0.026***	-0.033***	0.185***	-0.203***
	(-6.47)	(-10.03)	(4.59)	(-11.32)
Constant	9.676***	7.828***	—	—
	(16.01)	(13.77)	—	—
Industry	Yes	Yes	No	No
Province	Yes	Yes	No	No
Year	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	3386	2846	3386	2846
adj. R^2	0.528	0.482	0.322	0.299
F	35.112	25.297	41.682	67.390

Note: Period =0 refers to a steady period, and Period =1 refers to a shaky period. Columns (1) and (2) are OLS regression with industry, province, and year fixed effects controlled. Columns (3) and (4) are FE regression with firm and year fixed effects controlled. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.10: Inspection time periods and inspected provinces

Inspection batches	Provinces subjected to EICG
2016.1.1-2016.2.5	Hebei
2016.7.12-2016.8.19	Inner Mongolia, Heilongjiang, Jiangsu, Jiangxi, Henan, Guangxi, Yunnan, and Ningxia
2016.11.24-2016.12.30	Beijing, Shanghai, Hubei, Guangdong, Chongqing, Shanxi, and Gansu
2017.4.24-2017.5.28	Shanxi, Anhui, Tianjin, Hunan, Fujian, Liaoning, and Guizhou
2017.8.7–2017.9.15	Xinjiang, Zhejiang, Shandong, Hainan, Sichuan, Xizang, Qinghai, and Jilin

Note: EICG is conducted in 5 batches, with each lasting about one month. Several provinces are under inspection in each batch except for the pilot province Hebei.

TABLE 1.11: DID results for EICG

	(1) OLS	(2) OLS	(3) FE	(4) FE
CER	-0.110***	-0.036***	-0.049***	-0.042***
	(-10.17)	(-3.72)	(-4.19)	(-3.69)
CER*Inspect	0.077***	0.080***	0.073***	0.076***
	(5.21)	(6.14)	(5.37)	(5.78)
Inspect	-0.587***	-0.581***	-0.533***	-0.527***
	(-4.11)	(-4.70)	(-4.82)	(-4.93)
FA		-0.674***		-0.263
		(-5.69)		(-1.03)
CR		0.055***		-0.034
		(3.57)		(-1.55)
DEBT		-0.977***		-0.171
		(-7.89)		(-0.69)
LEVE		-0.025***		-0.031***
		(-6.13)		(-7.20)
SIZE		-0.228***		-0.578***
		(-16.33)		(-8.03)
AGE		-0.030***		0.049*
		(-11.52)		(1.82)
Constant	3.886***	8.841***	—	—
	(9.53)	(17.43)	—	—
Industry	Yes	Yes	No	No
Province	Yes	Yes	No	No
Year	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	6232	6232	6232	6232
adj. R^2	0.373	0.497	0.272	0.321
F	32.671	50.994	57.761	48.163
*Total effects of CER and CER*Inspect (using Wald test)*				
	-0.033***	0.044***	0.024**	0.034***

Note: Inspect captures whether the firm is after the inspection then. CER*Inspect captures the incremental impact of CER on firm value after the EICG. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.12: The parallel trends test

	(1) FE	(2) FE
CER	-0.043***	-0.041***
	(-3.23)	(-3.22)
CER_pre6	0.009	0.020
	(0.42)	(0.97)
CER_pre5	0.017	0.025
	(0.94)	(1.43)
CER_pre4	0.011	0.019
	(0.69)	(1.21)
CER_pre3	0.008	0.013
	(0.63)	(1.01)
CER_pre2	0.002	0.004
	(0.21)	(0.35)
CER_current	0.018**	0.022***
	(2.45)	(3.14)
CER_post1	0.043***	0.050***
	(4.10)	(4.83)
CER_post2	0.070***	0.081***
	(5.43)	(6.30)
CER_post3	0.077***	0.090***
	(4.67)	(5.46)
Controls	No	Yes
Year	Yes	Yes
Firm	Yes	Yes
N	6232	6232
adj. R^2	0.271	0.321
F	40.746	36.641

Note: $\text{Inspect}_{i,t}^{-j}$ equals one for region i in jth year before the EICG enforcement, $\text{CER}_{i,t} \times \text{Inspect}_{i,t}^{-j}$ captures the differences of CER effectiveness between treated group and control group in jth year before the policy. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.13: Placebo test results

	(1) Whole	(2) SOECG	(3) SOELG	(4) PE
CER*Period14	-0.010	-0.022	0.024	-0.040
	(-0.66)	(-0.83)	(1.18)	(-1.42)
CER*Period15	0.002	-0.001	0.024	-0.019
	(0.17)	(-0.02)	(1.31)	(-0.70)
CER*Period	0.062***	0.078***	0.054***	0.049*
	(4.61)	(3.24)	(2.75)	(1.95)
CER*Period17	0.094***	0.127***	0.078***	0.075***
	(7.23)	(5.26)	(3.90)	(3.27)
CER*Period18	0.088***	0.123***	0.078***	0.057**
	(7.10)	(5.46)	(4.36)	(2.36)
Controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
N	6232	1518	2242	2472
adj. R^2	0.194	0.229	0.191	0.217
F	126.055	34.577	44.084	60.321

Note: We use Period14 to represent the shaky period from 2014. CER*Period14 captures the incremental impact of CER on firm value in the assumed shaky period. The other interaction terms have similar meanings. We report all the assumed incremental impacts in this table. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.14: The moderating effect of ownership type using interaction terms

	(1) P= Period	(2)	(3) P= Inspect	(4)
CER	-0.041***	-0.037***	-0.048***	-0.041***
	(-3.40)	(-3.09)	(-4.09)	(-3.66)
CER* P	0.031*	0.048***	0.049***	0.065***
	(1.89)	(3.08)	(3.17)	(4.38)
CER*P*SOE	0.034***	0.017*	0.031***	0.014
	(3.49)	(1.77)	(3.34)	(1.56)
P	-0.973***	-3.334***	-0.411***	-0.472***
	(-3.02)	(-7.45)	(-3.49)	(-4.13)
FA		-0.272		-0.268
		(-1.07)		(-1.05)
CR		-0.036		-0.036
		(-1.60)		(-1.60)
DEBT		-0.171		-0.172
		(-0.68)		(-0.69)
LEVE		-0.031***		-0.031***
		(-7.26)		(-7.23)
SIZE		-0.564***		-0.566***
		(-7.76)		(-7.80)
AGE		0.270***		0.043
		(10.93)		(1.59)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
N	6232	6232	6232	6232
adj. R^2	0.274	0.320	0.275	0.321
F	58.908	48.390	55.906	46.550

Note: We use "P" to represent Period or Inspect. The coefficients of "CER*Period*SOE" represents the moderating effect of SOE on the incremental effect of CRE in the shaky period; "CER*Inspect*SOE" represents the moderating effect of SOE on the incremental effect of CRE after the inspection. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.15: The relation between CER and firm value in two periods controlling for investor sentiment

	(1) OLS	(2) OLS	(3) FE	(4) FE
CER	-0.108***	-0.022**	-0.043***	-0.034***
	(-9.72)	(-2.43)	(-3.47)	(-3.35)
CER*Period	0.069***	0.047***	0.054***	0.058***
	(4.74)	(4.52)	(3.78)	(4.63)
Period	-0.621**	0.244	-0.978***	-3.100***
	(-2.12)	(0.99)	(-3.04)	(-8.88)
FA		-0.554***		-0.367*
		(-6.22)		(-1.67)
CR		0.025**		-0.018
		(2.18)		(-1.08)
DEBT		-0.467***		-0.188
		(-4.92)		(-0.88)
LEVE		-0.015***		-0.020***
		(-4.97)		(-5.62)
SIZE		-0.370***		-0.574***
		(-30.47)		(-10.01)
AGE		-0.031***		0.250***
		(-14.40)		(13.68)
SENTIMENT		0.745***		0.538***
		(31.01)		(15.38)
Constant	3.827***	11.094***	2.530***	14.204***
	(10.33)	(30.96)	(8.00)	(11.35)
Industry	Yes	Yes	No	No
Province	Yes	Yes	No	No
Year	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	6037	6037	6037	6037
adj. R^2	0.358	0.690	0.128	0.373
F	30.251	111.095	125.852	218.712
*Total effects of CER and CER*Period (using Wald test)*				
	-0.039***	0.025***	0.011	0.024***

Note: We use "SENTIMENT" to represent investor sentiment. The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 1.16: The moderating effect of ownership type controlling for investor sentiment

	(1) SOECG	(2) SOELG	(3) PE	(4) SOECG	(5) SOELG	(6) PE
CER	-0.026*	-0.025	-0.019	-0.052***	-0.026	-0.022
	(-1.82)	(-1.40)	(-1.63)	(-3.09)	(-1.22)	(-1.51)
CER*Period	0.063***	0.051**	0.040***	0.085***	0.050**	0.039**
	(3.34)	(2.36)	(2.84)	(3.27)	(2.10)	(2.33)
Period	0.727***	-0.169	0.904***	-3.407***	-2.231***	-3.834***
	(2.83)	(-0.54)	(4.07)	(-4.07)	(-4.20)	(-7.45)
FA	-0.004	-0.648***	-0.845***	0.078	0.198	-1.424***
	(-0.02)	(-5.59)	(-3.99)	(0.27)	(0.77)	(-2.84)
CR	0.102***	-0.039*	0.003	0.073**	-0.008	-0.059***
	(2.94)	(-1.75)	(0.21)	(2.38)	(-0.22)	(-2.81)
DEBT	-0.102	-0.431***	-0.791***	0.044	0.301	-0.481
	(-0.56)	(-3.33)	(-3.86)	(0.15)	(0.82)	(-1.15)
LEVE	-0.008	-0.019***	-0.030***	-0.017***	-0.016***	-0.028***
	(-1.37)	(-5.37)	(-3.70)	(-3.46)	(-3.84)	(-2.96)
SIZE	-0.361***	-0.326***	-0.426***	-0.547***	-0.361***	-0.647***
	(-19.28)	(-16.92)	(-15.90)	(-6.98)	(-4.91)	(-5.92)
AGE	-0.010**	-0.006	-0.040***	0.183***	0.161***	0.342***
	(-2.31)	(-1.55)	(-10.40)	(7.26)	(5.99)	(10.06)
SENTIMENT	0.739***	0.657***	0.761***	0.627***	0.436***	0.530***
	(17.44)	(15.39)	(21.53)	(9.27)	(6.61)	(10.77)
Constant	9.121***	9.704***	11.782***	14.418***	8.894***	16.489***
	(18.07)	(15.94)	(22.00)	(7.58)	(5.86)	(7.03)
Industry	Yes	Yes	Yes	No	No	No
Province	Yes	Yes	Yes	No	No	No
Year	Yes	Yes	Yes	Yes	Yes	Yes
Firm	No	No	No	Yes	Yes	Yes
N	1483	2198	2356	1483	2198	2356
adj. R^2	0.763	0.666	0.682	0.463	0.312	0.395
F	52.852	44.791	44.963	72.231	63.943	97.460

Note: This table reports the OLS and fixed-effect (FE) regression results of ownership type subsamples controlling for investor sentiment. We report the OLS results with industry, province, and year fixed effects included in columns (1), (2), and (3), FE regression results with firm and year fixed effects included in columns (4), (5), and (6). The t-statistics (in parentheses) are based on heteroscedasticity-consistent standard errors. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Figures

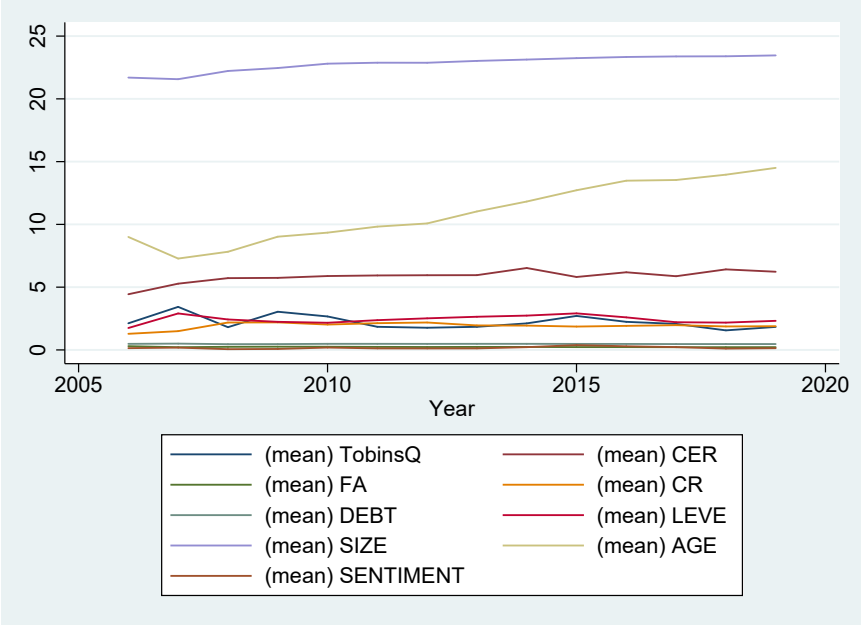

FIGURE 1.1: Trend of the means of variables over the years

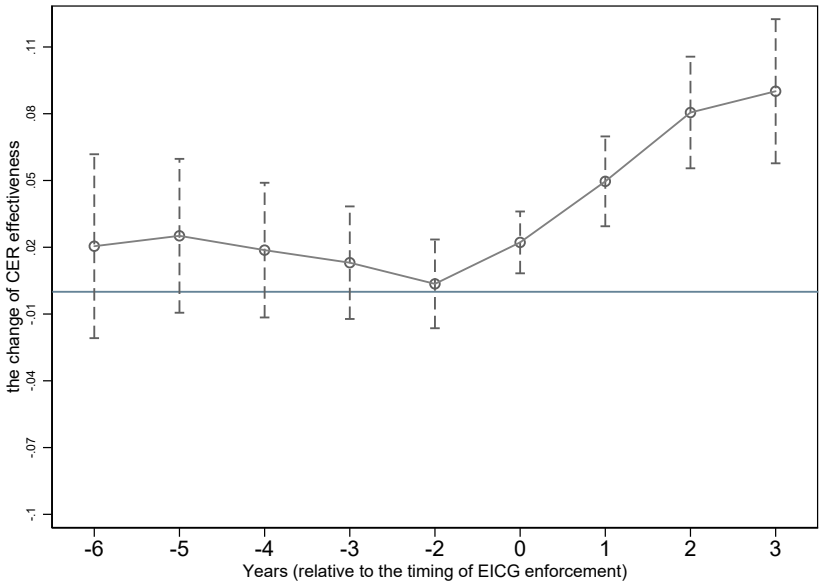

FIGURE 1.2: The parallel trends test results

Appendix: Measurement of investor sentiment

We calculate investor sentiment according to (Zhang and Zhu, 2014). The calculation process is: the market valuation level (average Q value) of a company is separated into an intrinsic value component containing its growth and a market mispricing component. Taking into account industry differences and market cycle fluctuations, the following cross-sectional regressions are performed for companies in each industry in each year:

$$Q_{i,t} = \beta_0 + \beta_1 \,\text{Size}_{i,t} + \beta_2 \,\text{Lev}_{i,t} + \beta_3 \,\text{ROA}_{\,i,t} + \varepsilon_{i,t} \tag{1.6}$$

Company size, leverage ratio, and profitability are included since they are the most important factors for fitting its intrinsic value. The sentiment index SENTIMENT is obtained after z normalization of the residual $Q^e_{i,t} = Q_{i,t} - Q^f_{i,t}$.

Chapter 2

The Non-monotonic Relationship Between ESG Disclosure and Stock Price Crash Risk

2.1 Introduction

Environmental problems like environmental pollution, ecological imbalances, and resource depletion can severely hinder economic development and social progress. With the growing public concern about intensifying environmental conservation to attain sustainable economic and social growth, sustainable development has gained more and more attention nowadays (Caiado et al., 2017). For example, some measures have been taken to alleviate environmental problems, such as the adoption of the 2015 Paris Climate Agreement, a legally binding international treaty on climate change, that aims to limit the increase in global average temperature to 2 °C. To achieve a win-win situation of economic development and environmental protection, corporate sustainability is also an essential part that should be seriously concerned (Lloret, 2016).

ESG[1] is increasingly becoming a consensus in recent years (Qiu and Yin, 2019). ESG is an extended notion of the green economy and responsible investment. It is currently an essential indicator for measuring enterprises' sustainable development level (Qiu and Yin, 2019). People from all walks of life, especially investors and financial practitioners, are growingly depending on ESG information and metrics to evaluate long-term company value[2][3] (Escrig-Olmedo et al., 2013). In the meantime, in response to increasing stakeholder interest in ESG, many related agencies, e.g., MSCI[4], Thomson Reuters, and Bloomberg started to report ESG and associated data.

Stock price crash risk[5] namely, extremely negative return outliers, are linked with the negative skewness of individual stock return distribution (Kim et al., 2014). It

[1]ESG has three dimensions, namely: environmental dimension (such as wastewater discharge, environmental penalties, etc.), social dimension (such as charitable donations, employee benefits, etc.), and governance dimension (such as board composition, political relations, etc.) .

[2]The Institute for Governance and Accountability (2017) reported that 82% of S&P 500 firms published sustainability reports in 2017, compared to 53% of S&P 500 firms in 2012.

[3]The SynTao Green Finance documented that about 1,021 (27%) A-share listed companies issued ESG reports in 2020 in China, among them, 259 (86%) of the CSI 300 listed companies released reports in 2020, indicating that the top listed companies already have a strong awareness of ESG disclosure.

[4]MSCI is an acronym for Morgan Stanley Capital International.

[5]Stock price crash risk and crash risk are interchangeable.

is the conditional skewness of return distribution.[6] This is crucial for investors to make investment judgments and conduct risk control (Chen et al., 2001). Crash risk is based on the idea that corporate managers often tend to hide negative news within the company from the outside market, which accumulates negative news over time. When managers prevent bad information from flowing into the market, the distribution of firms' stock returns will be an asymmetric shape (Hutton et al., 2009). If the collection of bad news exceeds a certain level, it will be instantly exposed to the market, causing a sharp decrease in stock price.

The relationship between ESG disclosure and crash risk is now examined in many developed countries. However, the empirical findings are mixed about whether ESG disclosure affects crash risk positively or negatively (Murata and Hamori, 2021). Besides, this relationship in China is worth special attention due to the following reasons. First, China starts ESG disclosure much later than developed countries and thus lacks efficient data evidence.[7] Second, the unique institutional background in China may lead to a distorted relationship, which is common in other economical research. Thus, although it is expected to be a significant link between ESG disclosure and crash risk based on prior research, we should be very careful about the investigation of the specific relationship. There are two dominant factors overall. First, a higher ESG score means a higher level of corporate information disclosure, less harmful news hoarding by managers, and higher transparency of the firm's financial reporting (Deng and Cheng, 2019). However, higher ESG is more likely to be used as a tool by managers to pursue their own interests, thereby reducing credibility level and increasing crash risk (Huang, 2021).

Kim et al. (2014) have examined the relationship between corporate social responsibility (CSR) and stock price crash risk. However, it is more beneficial to examine the ESG information and crash risk because of the difference between ESG

[6]Conditional skewness, defined as the third moment of the return distribution, is an essential feature of the return distribution, along with the mean (first moment) and variance (second moment).

[7]For example, the world's first ESG Domini 400 Social Index, later renamed as MSCI KLD 400 Social Index, was released in the United States in 1990. However, Chinese firms issued the first ESG report in 2006.

and CSR reports.[8] The difference between the two terms mainly contains three aspects. First, the target audience is different. The target audience of the CSR report is very scattered, while the ESG report is very focused.[9] Therefore, the report's content usually has a relatively "substantial" relationship with the company's stock market performance. Second, the frame and content are different. CSR reports are generally not mandatory, while ESG reports generally have relatively detailed guidelines and requirements.[10] This is reflected in the content, which requires coverage of specific content and even quantitative disclosure. Third, the release and use are different. The CSR report emphasizes dissemination and communication functions, and the release is flexible. While the ESG report is mainly for investors and has strict release requirements.[11] Some listed companies are beginning to realize the value of communicating with investors on ESG issues and use ESG reports as an important tool for investor communication.

This paper explores the connection between ESG disclosure and firm-specific stock price crash risk. Our methodology involves both analytical and reduced-form models. We first develop an analytical model based on two dominant factors and estimate the non-monotonic relationship. We then empirically estimate this relationship. The dataset covers panel observations of Chinese A-share listed companies from 2006 to 2020. The key variable, the ESG score, is collected from Bloomberg Professional Service and others are collected from China Stock Market & Accounting Research database and Wind database. The findings hold after robustness checks

[8]Previous studies like Kim et al. (2014) mainly concerned about the relation between the social dimension and firm-specific future stock crash risk. ESG is preferred to CSR, as it explicitly delineates its concerns (environmental, social, and governance).

[9]The CSR report audience is nearly all stakeholders, including government regulatory agencies, employees, partners, communities, and NGOs, and therefore the content of the CSR report has to be all-encompassing to meet the requirements of different sub-groups. The CSR report audience is mainly capital market participants, especially institutional investors.

[10]Companies have more freedom in preparing CSR reports, as long as they follow the general reporting framework, like the GRI standard, to expand the content, and it emphasizes the readability. However, in addition to referring to the GRI standards and other frameworks, it is also necessary for ESG reports to follow other specific requirements.

[11]CSR report pays special attention to the readability and dissemination of the report. There are various release forms, like the PDF version, H5 version, video version, etc. Some companies may organize special conferences or combine them with corporate brand activities. However, The ESG report must be released within the specified time, uploaded to the company's official website, and submitted to the exchange.

like addressing the endogenous concerns.

This paper contributes to the existing literature in the following three aspects. First, unlike existing research (e.g., Murata and Hamori, 2021) which provides only empirical evidence, we develop an analytical model to reveal the hidden mechanism. Second, our analytical model includes dominant factors in two competing theories, demonstrating that both theories work under different conditions. Our schema therefore can give a reasonable explanation of previously mixed findings. Third, our evidence from the updated Chinese dataset is rare and complementary to existing empirical research mostly in developed countries. The analytical model reveals the existence of a non-monotonic (negative with regard to the left-end boundary point but positive with regard to the right-end) relationship between ESG disclosure and crash risk. Our empirical results also verify this non-monotonic relationship using a Chinese dataset and support that the ESG disclosure level acts as a "market stabilizer" when the ESG score is low and acts as a "market destroyer" after the ESG score reaches a specific level. Therefore, the study offers consequential implications for the corporate manager and investor, as well as policymaker and regulator. Specifically, transparency and credibility of the financial report are two positive factors that make ESG more valuable.

The rest of this chapter is arranged as follows. We discuss the prior research in the next section. Section 2.3 presents the literature evidence of non-monotonic. Section 2.4 is the analytical model, revealing the non-monotonic relation. Section 2.5 provides a reduced-form analysis, verifying a non-monotonic relationship. Section 2.6 presents our empirical results. Section 2.7 concludes the chapter.

2.2 Literature review

2.2.1 Environmental, social and governance

The ESG literature has mainly focused on the link between ESG and financial performance (Xie et al., 2019). Some academics examine whether the ESG score could

be considered a probable essential element for successful investment (Richardson, 2009), and whether investors are more willing to invest in companies with a more satisfactory CSR profile, which might lead to more promising financial performances (De Bakker et al., 2005). Regarding the relationship between ESG and firm performance, two opposite views prevail. On the one hand, based on the Porter hypotheses (Porter and Linde, 1995), corporate social responsibility engagement, primarily environmental responsibility engagement, can stimulate firm innovative behavior that generates additional gains to offset costs. Thus a suitable CSR approach may improve corporate financial performance (CFP). Numerous empirical investigations find CSR is positively related to CFP (Deng et al., 2013). On the other hand, CSR activities bring additional costs caused by inefficient resource allocation, which will make the firm less competitive in the free and competitive market (Sternberg, 1997). Much research uncovered that CSR is negatively correlated with a firm's financial performance (Margolis and Walsh, 2003). Different from the positive or negative associations, some researchers saw a neutral association between CSR and CFP (McWilliams and Siegel, 2001; Moore, 2001). Besides the relationship of ESG to FP, some studies suggest other factors that can strengthen or weaken this relationship, such as innovation, long-term orientation (Wang and Bansal, 2012), stakeholder relations, managerial action, financial Slack, and so on (Kim and Statman, 2012; Duque-Grisales and Aguilera-Caracuel, 2019).

The connection between ESG and firm-level stock return has also been explored. Belkaoui (1976) is one of the first scholars to study the linkage between corporate exposure to environmental information and stock performance. His research uncovered that companies that reported environmental information underperformed others before publishing it and surpassed them afterward. Klassen and McLaughlin (1996) propose an analytical model that supports the notion that environmental performance awards are associated with significantly positive returns whereas

environmental crises are heavily correlated with significant negative returns. Graham and Maher (2006) support a negative association between environmental risk management and corporate bond ratings or yields. More recently, Kim et al. (2014) investigate how CSR impacts stock price crash risk and shows a negative influence of CSR on crash risk. Demers et al. (2020) investigate whether ESG scores could function as indicators of share price resilience during the COVID-19 humanitarian crisis and documented that ESG scores offer no such positive explanatory power for returns during COVID-19.

2.2.2 Stock price crash risk

There is a myriad of literature on stock price crash risk, and we can divide them into five groups. The first group studies determinants of financial reporting and corporate disclosures. Hutton et al. (2009) use the cumulative accrual to measure a firm's earnings management, and the findings demonstrate that companies with more opaque economic information are prone to experience share price crashes. Chen et al. (2017) find that companies with smoother earnings are more prone to share price crashes. DeFond et al. (2015) investigate the effect of adopting different accounting standards on corporate crash risks and discover that adopting International Financial Reporting Standards (IFRS) would reduce a company's crash risk. Zhang et al. (2016) explore the impact of corporate philanthropy (an important part of CSR) on the collapse risk of Chinese companies and verify that it decreases the collapse risk.

The second group of determinants is about managerial incentives and characteristics. Kim et al. (2011) study the impact of CFO equity incentives in compensation plans on businesses' crash risk. Their results show that the higher the CFO option portfolio value ratio, the greater the company's crash risk. Park (2017) finds that differences in the compensation of corporate employees could increase corporate real revenue management (REM) behaviors, accordingly adding the risk of corporate

stock price plummeting.

The third group of determinants is related to the capital market. Chen et al. (2001) believe that the trading volume of stocks mirrors the divergence of market investors. Therefore, higher stock trade volume exhibits that some investors perceive negative information inside the company. Callen and Fang (2015) demonstrate that short interest in a company's stock is associated with its risk of a future crash. Ni and Zhu (2016) state that the crash risks of stock prices in the market would increase when short-selling restrictions were removed.

The fourth group is about corporate governance. Andreou et al. (2016) show that companies with a high percentage of independent directors and strict governance policies have a lower probability of collapse. Xu et al. (2014) point out that the perk system of state-owned enterprises will encourage managers to conceal negative news for their own benefit, leading to increased crash risks. Boubaker et al. (2014) find that excessive control is positively correlated with stock crashes.

The fifth group is regarding informal institutional mechanisms. Luo et al. (2016) show that companies with political ties to government officers are less at risk of collapse. Li and Chan (2016) discover that holding members of the Chinese Communist Party (CPC) on the board reduces the collapse risk of the company. Li et al. (2017) explore how social confidence and firms' crash risk link, and the results show that companies located in areas with high social confidence levels generally have lower crash risk.

2.3 Literature evidence of the non-monotonic relationship

2.3.1 Benefits of ESG disclosure

There are two opposite views of the effect of ESG on firm-specific crash risk based on earlier literature. Some researchers support a negative relationship since high ESG disclosure helps to mitigate managers' negative news hoarding activities and enhance transparency in firms' financial reports. For example, Gelb and Strawser

(2001) uncover that companies that engage in more socially responsible activities tend to supply better financial information disclosures. Because companies with high corporate social responsibility usually have high ethical standards and better information transparency. Eccles et al. (2014) discover that more long-term oriented, highly sustainable companies had better ESG measures and exposure patterns. Non-financial reports could be employed to forecast the anticipated forthcoming economic performance of the company. Investing with consideration of ESG information can help investors bypass 90% of bankruptcies (Lynch and Morgan, 2017). Wu and Hu (2019) reveal a lower crash risk for such firms with high CSR scores. Other researchers, such as Cheng et al. (2014), argue that companies with high ESG transparency have better operational reputations and are more likely to acquire funds at lower costs.

Besides, the stakeholder perspective suggests that stakeholders and firms mutually influence each other (Feng et al., 2021). Higher ESG disclosure helps firms enhance their reputation, which benefits the improvement and maintenance of the firm value. For instance, the Legitimacy Theory view claims that a company's ESG disclosure aims to gain social legitimacy for the environmental or social influences of the company's operations (Lokuwaduge and Heenetigala, 2017). Amid the pressure of the public and stakeholders, ESG disclosure is a good management tool for maintaining a favorable corporate reputation for the enterprise (Brammer and Pavelin, 2008). CSR, as an intangible asset, can strengthen the reputation of companies, improve performance and safeguard the interests of shareholders in the long run (Dai et al., 2019).

2.3.2 Costs of ESG disclosure

By contrast, there is a concern about agency problems that managers may use ESG opportunistically for personal gain. For example, Friedman (2007) argues that CSR

may be a kind of agency problem, as companies may employ CSR to conceal corporate misconduct. Consistent with this notion, Petrovits (2006) and Prior et al. (2008) find that CSR boosts a firm's earnings management behaviors. If a firm uses ESG score as a mask to conceal poor information and shift shareholder inspection (Kim et al., 2014). To avoid reputation loss, managers are likely to use the ESG disclosure as a self-interest tool to get promoted, which significantly undermines information transparency (Barnea and Rubin, 2010). Companies with poor performance or earnings management and corruption are more likely to carry out charitable, public welfare, environmental protection, and other social responsibility activities to avoid punishment and show a good image to external stakeholders (Barnea and Rubin, 2010).

2.3.3 Reconciling the contradictory theoretical concepts

Two main competing perspectives about the relationship exist in the previous literature. One is the stakeholder perspective, which suggests that higher ESG disclosure means lower crash risk. Since a high ESG score reflects that the firm values long-term performance and has a more transparent information disclosure system, it establishes reputational capital and thus reduces crash risk. The other is the agency perspective, which claims that higher ESG disclosure leads to higher crash risk. Because of the interest conflict between shareholders and managers, the managers might construct an illusion of a high ESG level to obtain personal gain, which retains bad news in firms and increases the crash risk.

Thus, the nature of the ESG-crash risk relationship may be more complex than a simple positive or negative one. It appears that there may exist conflicts between the two and the relationship assessment also depends on the level of the ESG disclosure. The law of diminishing marginal returns supports the theory of the "too-much-of-a-good-thing" effect, which can serve as an explanation of why beneficial expectations (ESG disclosure) might lead to negative outcomes (crash risk) when

they are beyond a certain level, where the costs exceed benefits. The "too-much-of-a-good-thing" effect assumes that the relationship between two objects has a specific maximum, after which an extra rise introduces a decrease in the consequence, resulting in a non-monotonic link, like the Environmental Kuznets Curve (Trumpp and Guenther, 2017; Aghion et al., 2019; Andreoni and Levinson, 2001). Therefore, an inflection point of the ESG level appears when the stock price crash risk reaches its minimum (the optimal level), and after that, there is a positive link (Pierce and Aguinis, 2013). In a word, it is necessary to find a balance between the two extremes.

Therefore, we hypothesize that there is a non-monotonic relationship between the ESG disclosure level and the stock price crash risk. When the ESG disclosure level is low, the increased ESG disclosure indicates a higher level of transparency and higher stakeholder benefits, which leads to less bad news hoarding. As the ESG disclosure level rises to a certain level in China, ESG report is more used as a self-interest tool for management, it may bring additional costs caused by agency problems and inefficient resource allocation, which would make the firms in an unfavorable position and increase the stock price crash risk.

2.4 Analytical model of the non-monotonic relationship

A non-monotonic function is a function that does not always increase or decrease. A function is non-monotonic if its first derivative (which does not have to be continuous) changes sign. The mathematical definition of a non-monotonic function $y(x)$ is, if there are two different x_1 and x_2 in the domain of x, such that $\frac{dy}{dx_1} * \frac{dy}{dx_2} < 0$, then y and x have a non-monotonic relationship.

According to the above literature review, there are two competing perspectives on the ESG-crash risk relationship. One is the stakeholder perspective, which suggests that high ESG companies are committed to long-term firm value and stakeholder trust building. Therefore, high ESG companies will provide more transparent information (in this case, high ESG means high transparency and low crash risk).

The other is the agency perspective, which means that when a company's shareholders and managers have conflicting interests, managers will harm shareholders' interests and maximize their own interests. Therefore, high ESG may be a tool for managers to seek their personal interests (high ESG means low credibility and high crash risk). The relationship between ESG and crash risk is affected by both channels.

2.4.1 Model setup

A company's cash flow (C_t) production process is as follows:

$$C_t = K_0 X_t \tag{2.1}$$

where K_0 is a constant, representing the initial investment, and X_t is the shocks that affect the cash flow-generating process. X_t is the sum of three independent parts:

$$X_t = f_t + \theta_{1,t} + \theta_{2,t} \tag{2.2}$$

Here f_t captures a macroeconomic factor that affects all firms in the market and is known by all people. $\theta_{1,t}$ and $\theta_{2,t}$ capture firm-specific factors. $\theta_{1,t}$ is public information, such as annual financial reports, news, etc. $\theta_{2,t}$ is information within the firm, such as negative news hidden by managers. The managers inside the company observe both $\theta_{1,t}$ and $\theta_{1,t}$, but outsiders only know $\theta_{1,t}$. $\theta_{1,t}$ and $\theta_{2,t}$ are independent of each other. For simplicity and rationality, we assume that f_t, $\theta_{1,t}$ and $\theta_{1,t}$ are stationary AR(1) with the same AR(1) parameter φ ($0 < \varphi < 1$). We assume that the error terms, ε_{t+1}, $\xi_{1,t+1}$, and $\xi_{2,t+1}$ are all normally distributed with mean 0 and variance 1. That is:

$$\begin{aligned} f_{t+1} &= f_0 + \varphi f_t + \varepsilon_{t+1}, \\ \theta_{1,t+1} &= \theta_{1,0} + \varphi\theta_{1,t} + \xi_{1,t+1}, \\ \theta_{2,t+1} &= \theta_{2,0} + \varphi\theta_{2,t} + \xi_{2,t+1}, \end{aligned} \tag{2.3}$$

Thus, X_t is also stationary AR(1):

$$X_{t+1} = X_0 + \varphi X_t + \lambda_{t+1} \tag{2.4}$$

where $X_0 = f_0 + \theta_{1,0} + \theta_{2,0}$, and $\lambda_t = \varepsilon_t + \xi_{1,t} + \xi_{2,t}$.

Next, we define κ as the ratio of firm-specific to market variance:

$$\kappa = \frac{\text{Var}\left(\theta_{1,t} + \theta_{2,t}\right)}{\text{Var}\left(f_t\right)} \tag{2.5}$$

And we define a firm's transparency as the ratio of the variance of $\theta_{1,t}$ to the sum of the variances of $\theta_{1,t}$ and $\theta_{2,t}$:

$$\eta = \frac{\text{Var}\left(\theta_{1,t}\right)}{\text{Var}\left(\theta_{1,t} + \theta_{2,t}\right)} = \frac{\text{Var}\left(\theta_{1,t}\right)}{\text{Var}\left(\theta_{1,t}\right) + \text{Var}\left(\theta_{2,t}\right)}, \tag{2.6}$$

The second equation holds because $\theta_{1,t}$ and $\theta_{2,t}$ are independent of each other.

2.4.2 Transparency and crash risk are negatively related

Given the company's current (t) stock price, the return for the next period ($t+1$) depends on two factors. One is market factor $\tilde{\varepsilon}_{t+1}$, captured by the market return $r_{m,t+1}$; and a firm-specific factor $\tilde{\xi}_{t+1}$. Thus, R^2 of a firm, represented by the portion of variance explained by the market is:

$$R^2 = \frac{\text{Var}\left(\varepsilon_{t+1}\right)}{\text{Var}\left(\varepsilon_{t+1}\right) + \text{Var}\left(\xi_{t+1}\right)} = \frac{1}{\kappa\eta + 1} \tag{2.7}$$

Here κ is the ratio of firm-specific to market variance, defined in Formula (2.5). η is the firm's transparency, defined in Formula (2.6). From the equation, we found

that, when other things are equal, the less transparent the company is, the greater the R^2. In other words, transparency is inversely proportional to R^2.

Next, we want to show that crash risk is proportional to R^2. Jin and Myers (2006) state that stocks have higher R^2 in less developed countries. Higher R^2 means a higher portion of variance explained by the market. In developing countries (with immature financial markets), such as China, where external regulation is weak, company managers are more likely to steal company profits for their own benefit. We assume managers can take away money, and the takeaways depend on market expectations. In this case, if the macroeconomic environment improves year by year and the company's actual profit is 50, 100, and 200 for three consecutive years, the manager would steal 10, 50, and 125 in these three years, respectively. Ultimately, the amount of profit that the company presents to the market is the actual profit minus stealing by managers, namely, 40, 50, and 75. However, in developed countries (with sound financial markets), it is more difficult for companies to manipulate profits due to sound laws, regulations, and supervision systems. Since crash risk means negative news hoarding or potentially exposed takeaway, a high R^2 implies a high level of bad news hoarding or high crash risk. In other words, R^2 is proportional to crash risk, $R^2 \propto$ crash risk. Combining the above formula (2.7), we obtain the following formula:

$$\text{Crash risk} \propto \frac{1}{\kappa\eta + 1} \tag{2.8}$$

Crash risk is inversely proportional to transparency.

2.4.3 Transparency and ESG score are positively related

Companies with high ESG scores disclose more ESG-relevant information to the market, which is itself a reflection of high transparency. Therefore, we believe that ESG score and transparency are positively related. We assume that this positive relationship satisfies the following, $\eta(ESG = 0) > 0$, $\eta' > 0$ and $\eta'' < 0$. This assumption is reasonable. $\eta(ESG = 0) > 0$ is established because even if no ESG

information is disclosed, the company still has positive transparency due to other disclosures, such as financial reports. $\eta' > 0$ is established because ESG disclosure is a form of information disclosure. The higher the ESG score, the more information is revealed, thus higher transparency. $\eta'' < 0$ is established because, intuitively, when the level of ESG disclosure is low, the increased ESG disclosure at this time is important information, resulting in a rapid increase in transparency. When the level of ESG disclosure is high, the increased ESG disclosure at this time is trivial information and has little impact on the improvement of transparency.

2.4.4 Credibility and crash risk are negatively related

When there exists negative $\theta_{2,t}$, namely bad news hoarding inside the firm, managers have two options. One is to stay with the company and continue to hide bad news. Then managers will need to pay a certain cost to cover up the bad news. The other is giving up hiding bad news (like leaving the company and getting some money). For the first option, managers need to pay a certain amount in the current year and future to cover up the bad news. We discount future money to the current period. According to Myers (2000), the following formula expresses managers' total cost of sticking with the company to cover up bad news.

$$\begin{aligned} &K_0\theta_{2,t} + PV\left\{K_0\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right), K_0\mathrm{E}\left(\theta_{2,t+2} \mid \theta_{2,t}\right), \ldots; r\right\} \\ &= K_0\left[\theta_{2,t} + \frac{1}{r}\frac{\theta_{2,0}}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left(-\frac{\theta_{2,0}}{1-\varphi} + \theta_{2,t}\right)\right] \end{aligned} \tag{2.9}$$

Here, PV stands for discounting future amounts to the current period. r is the risk-free rate. φ $(0 < \varphi < 1)$ is the AR(1) parameter of $\theta_{2,0}$. $\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right)$ is the conditional expectation of $\theta_{2,t+1}$ given $\theta_{2,t}$. $K_0\theta_{2,t}$ means the cost in period t for managers to cover up bad news $(\theta_{2,t})$. $PV\left\{K_0\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right), K_0\mathrm{E}\left(\theta_{2,t+2} \mid \theta_{2,t}\right), \ldots; r\right\}$ means discounted future costs to period t (given $\theta_{2,t}$).

Under the second option, managers give up hiding bad information, abandon the company, and get a one-time income. This income is related to the market's

valuation of the company. According to Myers (2000), the overall valuation of the company by external investors can be expressed as follows:

Manager's stick cost=

$$\begin{aligned} \mathrm{E}\left(K_t \mid f_t, \theta_{1,t}\right) &= \frac{1}{r}\frac{K_0 X_0}{1-\varphi} - \frac{\varphi}{1+r-\varphi}\frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi} K_0 \left(f_t + \theta_{1,t} + \frac{\theta_{2,0}}{1-\varphi}\right) \\ &= \frac{1}{r}\frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left[K_0\left(f_t + \theta_{1,t} + \frac{\theta_{2,0}}{1-\varphi}\right) - \frac{K_0 X_0}{1-\varphi}\right] \end{aligned} \tag{2.10}$$

We assume that credibility will affect the lowering of the market's valuation of the company and that managers get paid $p(0 < p < 1)$ times the company's overall valuation. Therefore, the amount that the manager can get at this time can be expressed as:

Manager's gain=

$$p * (\text{ credibility }) \left\{\frac{1}{r}\frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left[-\frac{K_0 X_0}{1-\varphi} + K_0\left(f_t + \theta_{1,t} + \theta_{2,t}\right)\right]\right\} \tag{2.11}$$

The indifference condition (both options[12] are equivalent for managers) of managers is:

$$\begin{aligned} &\mathrm{K}_0\left[\theta_{2,t} + \frac{1}{r}\frac{\theta_{2,0}}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left(-\frac{\theta_{2,0}}{1-\varphi} + \theta_{2,t}\right)\right] \\ &+ p * \text{ credibility } \left\{\frac{1}{r}\frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left[-\frac{K_0 X_0}{1-\varphi} + K_0\left(f_t + \theta_{1,t} + \theta_{2,t}\right)\right]\right\} = 0 \end{aligned} \tag{2.12}$$

We can see that the higher credibility, the more managers can obtain from the firm, and the less likely they will ditch the company (release bad news). Therefore, we prove that credibility is negatively related to crash risk.

2.4.5 Credibility and ESG score are negatively related

According to agency theory, when there is interest conflict between shareholders and managers, the managers might construct an illusion of a high ESG level to obtain

[12]Specifically, option one is that managers choose to pay a certain amount in the current year and in the future to cover up the bad news; option two is that managers give up hidden information, abandon the company, and get a one-time income.

personal gain, which retains bad news in firms and increases the crash risk. Therefore, there is a negative relationship between ESG scores and credibility. We assume that this negative relationship satisfies the following, $z_2(ESG = 0) = maximum > 0$, $z_2' < 0$ and $z_2'' < 0$. This assumption is reasonable. $z_2(ESG = 0) = maximum > 0$ is established because when no ESG information is disclosed, the possibility of ESG being used by managers as a tool for personal gain is 0, so the credibility is the highest. $z_2' < 0$ is established because as ESG disclosure increases, ESG is more likely to be used by managers as a tool for personal gain and thus lower credibility. $z_2'' < 0$ is established because, intuitively, when the level of ESG disclosure is low, the increased ESG disclosure at this time is more likely to be true information, and the decrease in credibility is not obvious. When the level of ESG disclosure is high, managers are likely to whitewash ESG performance to achieve personal goals or hide bad news, and credibility declines faster as ESG increases.

2.4.6 Formula simplification for crash risk function on transparency and credibility

According to proposition 4 in Jin and Myers (2006)[13], the return process of a firm's stock satisfies the following formula:

$$\tilde{r}_{i,t+1} = r + \frac{(1+r)\left(\tilde{\varepsilon}_{t+1} + \tilde{\xi}_{t+1}\right)}{X_0(1+r)/r + \varphi\left(f_t + \theta_{1,t}\right)} \tag{2.13}$$

Where $\tilde{r}_{i,t+1}$ is excess rate of return. r is the risk-free rate, From the above formula, we can see that $\tilde{r}$ is inversely proportional to $\frac{1}{\theta_1}$, namely:

$$r \propto \frac{1}{\theta_1} \tag{2.14}$$

We assume r_- is the excess rate of return at times of stock crash. When the negative news (θ_2) is exposed to investors, the stock price will fall sharply (crash).

[13] It is shown on page 268.

Similar to the above formula, we can infer that r_- satisfies the following formula:

$$r_- \propto \frac{1}{\theta_1 + \theta_2} \tag{2.15}$$

We calculate the crash risk as the proportion of the standard deviation of stock returns on "down" days to that on all days. And since $\mathrm{Var}(X) = \mathrm{E}\left[X^2\right] - \mathrm{E}[X]^2$, we obtain the following formula for crash risk.

$$\text{Crash risk} = \frac{\sum r_-^2}{\sum r^2} = \frac{\sum \mathrm{var}\left(r_-\right)}{\sum \mathrm{var}(r)} \tag{2.16}$$

Then we substitute formulas (2.14) and (2.15), and obtain:

$$\text{Crash risk} = \frac{\sum_{T-} \mathrm{var}\left(\frac{1}{\theta_1+\theta_2}\right)}{\sum_T \mathrm{var}\left(\frac{1}{\theta_1}\right)} \tag{2.17}$$

Since $\sum_{r-}$ equals total days multiplied by the probability of negative returns, $\sum_r$ equals total days. Meanwhile, according to the equation formula of the function $\mathrm{var}(f(x)) = \left(f'(E(x))\right)^2 \mathrm{Var}(x)$, we transform the above formula into the following:

$$\text{Crash risk} \propto \frac{T \cdot P_{r_-} \cdot \mathrm{var}\left(\theta_1 + \theta_2\right)}{T \cdot \mathrm{var}\left(\theta_1\right)} = P_{r_-} \cdot \frac{1}{\eta} \tag{2.18}$$

P_{r_-} represents the probability of occurrence of r_-. It can be seen from the above equation that when only considering transparency, the risk is inversely proportional to transparency. This is consistent with intuition.

We then simplify P_{r_-}. The indifference condition for managers are:

$$\begin{aligned} &\mathrm{K}_0 \left[\theta_{2,t} + \frac{1}{r}\frac{\theta_{2,0}}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left(-\frac{\theta_{2,0}}{1-\varphi} + \theta_{2,t}\right)\right] \\ &+ p * (\text{ credibility }) \left\{\frac{1}{r}\frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left[-\frac{K_0 X_0}{1-\varphi} + K_0\left(f_t + \theta_{1,t} + \theta_{2,t}\right)\right]\right\} = 0 \end{aligned} \tag{2.19}$$

Because other factors are constants, we can simplify the two parts before and after the plus sign into $-\beta_1\theta_2$ and $z_2 \cdot \beta_2 \cdot (\theta_1 + \theta_2)$. Here, we describe the constant

term before θ_2 as β_1. We add the "negative sign" to indicate that this is the manager's pay (cost). we describe the constant term before $(\theta_1 + \theta_2)$ as β_2. For brevity, we use z_2 to represent credibility.

Therefore, we get the following:

$$P_{r\_} = \text{Possibility of releasing bad news} \quad = P\left\{-\beta_1\theta + z_2\beta_2 \cdot (\theta_1 + \theta_2) < 0\right\} \tag{2.20}$$

$$\begin{aligned}
&-\beta_1\theta + z_2 \cdot \beta_2 \cdot (\theta_1 + \theta_2) \\
&= (\theta_1 + \theta_2)\left[-\frac{\beta_1\theta_2}{\theta_1 + \theta_2} + z_2\beta_2\right] \\
&= (\theta_1 + \theta_2)\left[-\beta_1\left(1 - \frac{\theta_1}{\theta_1 + \theta_2}\right) + z_2\beta_2\right] \\
&= (\theta_1 + \theta_2)\left[-\beta_1(1 - \eta) + z_2\beta_2\right] \\
&\propto \beta_1\eta + \beta_2 z_2
\end{aligned} \tag{2.21}$$

Thus,

$$\text{Crash risk} = \frac{1}{\eta}P\left\{\eta + z_2 < 0\right\} \tag{2.22}$$

For η (transparency), when η is larger, $\frac{1}{\eta}$ is smaller, p is smaller, and finally the crash risk becomes smaller. For z_2 (credibility), when z_2 is larger, the crash risk becomes smaller. Therefore, for both transparency and credibility, the risk is inversely proportional to them. This is also consistent with intuition.

2.4.7 Obtain the non-monotonic relation

Based on reasonable assumptions about the relationship of ESG to the two channels (transparency η and credibility z_2) in subsections (2.4.3) and (2.4.5),[14] and the simplified formula for crash risk function on transparency and credibility shown in equation (2.22), we first illustrate the existence of a non-monotonic relationship by specifying the trends of the two boundary points.

[14]Specifically, for η, $\eta' > 0$ and $\eta'' < 0$; for z_2, $z_2' < 0$ and $z_2'' < 0$.

The trend of the left boundary point (when ESG is close to the minimum value, that is, the company does not disclose ESG information) is as follows: When ESG increases, η increases substantially and z_2 decreases by a small amount (or almost unchanged). It can be seen from equation (2.22) that a large increase in η causes a large decrease in crash risk; a small reduction in z_2 results in a tiny increase in crash risk. Therefore, at the left boundary point, when ESG rises, the combined effect of η and z_2 causes a decrease in crash risk. This means that the relationship between ESG and crash risk is negative at the left boundary point, namely, $\frac{d_{Risk}}{d_{ESG_{low}}} < 0$.

The trend of the right boundary point (when ESG is close to the maximum value, that is, the company almost fully discloses ESG information) is as follows: When ESG increases, η increases by a small amount (or almost unchanged) and z_2 decreases substantially. It can be seen from equation (2.22) that the slight increase in η causes a slight decrease in crash risk; a large reduction in z_2 results in a large increase in crash risk. Therefore, at the right boundary point, when ESG rises, the combined effect of η and z_2 causes an increase in crash risk. This means that the relationship between ESG and crash risk is positive at the right boundary point, namely, $\frac{d_{Risk}}{d_{ESG_{high}}} > 0$.

So far, we have verified $\frac{d_{Risk}}{d_{ESG_{low}}} < 0$ exists when ESG is small (close to the minimum value), $\frac{d_{Risk}}{d_{ESG_{high}}} > 0$ exists when ESG is large (close to the maximum value). Therefore, $\frac{d_{\text{Risk}}}{d_{ESG_{low}}} * \frac{d_{\text{Risk}}}{d_{ESG_{high}}} < 0$, which shows that there is a non-monotonic relationship between ESG and crash risk.

Furthermore, we could select three ESG values to verify the possible non-monotonic relationship between ESG and crash risk. When ESG takes values 1, 20, and 40, respectively (that is, $ESG_1 = 1$, $ESG_2 = 20$, and $ESG_3 = 40$; $ESG_1 < ESG_2 < ESG_3$), it is reasonable that η (transparency) takes the values of 5, 14, and 15, respectively. And z_2 (credibility) takes the values of 15, 14, and 5, respectively. Therefore, we get three pairs of (transparency, credibility), that is, (5,15), (14, 14), and (15, 5). Substituting these three pairs of values into (2.22), we get the values of crash

risk as $\frac{1}{5}P(20)$, $\frac{1}{14}P(28)$, $\frac{1}{15}P(20)$. The size relationship between them is $\frac{1}{5}P(20) > \frac{1}{15}P(20) > \frac{1}{14}P(28)$, namely $Risk_1 > Risk_3 > Risk_2$.

2.5 Research design

2.5.1 Data and sample

Our initial sample contains all firms listed on the A-shares (RMB ordinary stock) from China Security Market from 2005 to 2020. Please note that the ESG scores and control variables are gathered from 2005-2019, and crash risk data is calculated from 2006-2020. Then, we impose the following requirements: (1) excluding enterprises in the financial sector, (2) excluding enterprises with fewer than thirty trading weeks in one year, and (3) excluding observations with missing data. Our sample finally includes 6777 observations with 1017 firms and ranges 16 years. We next winsorize all the continuous variables at 1% and 99% percentages to ease the outliers' influences. Data are collected from China Stock Market & Accounting Research Database (CSMAR), Wind database, and Bloomberg Professional Service. The specific data sources for each variable are shown in Table 2.1.

[Table 2.1]

2.5.2 Measurement of crash risk

Following the prior research, such as Kim et al. (2014) and Zhang et al. (2016), we use two indexes to evaluate a firm's crash risk: the first one is the negative coefficient of skewness of a firm's weekly stock returns ($NCSKEW_{i,t}$); the other is the crash likelihood estimation of the Down-to-Up Volatility ($DUVOL_{i,t}$) of a firm's stock returns. To calculate them, we need first calculate the firm's weekly returns ($W_{i,t}$), defined as the natural logarithm of one plus the residual term, which is obtained from below the market model regression:

$$R_{i,t} = \alpha_i + \beta_1 R_{m,t-2} + \beta_2 R_{m,t-1} + \beta_3 R_{m,t} + \beta_4 R_{m,t+1} + \beta_5 R_{m,t+2} + \varepsilon_{i,t} \tag{2.23}$$

where $R_{i,t}$ is firm i's stock return during week t. $R_{m,t-2}$, $R_{m,t-1}$, $R_{m,t}$, $R_{m,t+1}$, and $R_{m,t+2}$ are market returns of total value-weighted market index during weeks $t-2$, $t-1$, $t-1$, $t+1$, and $t+2$, respectively. $\varepsilon_{i,t}$ is the residual term.

Then, firm-specific weekly returns ($W_{i,t}$)[15] are calculated below:

$$W_{i,t} = \ln(1 + \varepsilon_{i,t}) \tag{2.24}$$

Next, $NCSKEW_{i,t}$, is computed via the third moment of firm i's weekly stock returns in year t, divided by the cubed standard deviation of a firm's weekly returns, then multiplied by a negative one. The calculation formula is explicitly shown as follows:

$$NCSKEW_{i,t} = -\left[n(n-1)^{3/2}\sum W_{i,t}^3\right] / \left[(n-1)(n-2)\left(\sum W_{i,t}^2\right)^{3/2}\right] \tag{2.25}$$

Here n represents the total number of trading weeks of firm i in year t. From the equation, we know that when $NCSKEW_{i,t}$ rises, the left skewness of the distribution of the excess returns will be more significant, which indicates a higher crash possibility.

Then, we evaluate $DUVOL_{i,t}$, which is formed by taking the logarithm of the proportion of the standard deviation of a firm's weekly stock returns in "up" weeks to that in "down" weeks. Up and down weeks are obtained by comparing returns in that week with a firm's average weekly returns for the year t. When the weekly stock return is larger than the average value, this is an "up" week; when the firm's weekly stock return is smaller than the average value, this is a "down" week. The calculation process is shown below:

$$DUVOL_{i,t} = \log\left\{\left[(n_u - 1)\sum_{DOWN} W_{i,t}^2\right] / \left[(n_d - 1)\sum_{UP} W_{i,t}^2\right]\right\} \tag{2.26}$$

Here n_u (n_d) indicates the week's number that firm i' weekly stock returns are

[15] When $\varepsilon_{i,t}$ is less than -1, $W_{i,t}$ is a missing value. Here 36 observations were deleted.

higher (lower) than the average weekly stock returns during the year t. High $DUVOL_{i,t}$ implies high crash risk.

2.5.3 Environmental, Social and Governance information

We use ESG scores obtained from the Bloomberg Professional Services platform. Its ESG information is primarily gathered from corporate sustainability reports, financial reports, and firms' news and announcements. The ESG disclosure score measures the transparency of ESG information, and the scoring process takes into account disparities in importance and industry distinctions for each data point. Bloomberg's ESG data varies from 0.1 to 100, with the two extremes representing the minimum level of disclosure and disclosure of all relevant information, respectively.

2.5.4 Empirical model

To investigate the relationship between firm ESG disclosure and stock price crash risk, we construct the following regression model:

$$CrashRisk_{t+1} = \beta_0 + \beta_1 ESG_t + \beta_2 ESG_t^2 + \beta_3 Controls_t + \text{Industry} + \text{Year} + \varepsilon_t \quad (2.27)$$

Here the dependent variable, $CrashRisk_{t+1}$, is derived from $Ncskew$ or $Duvol$. ESG is the key independent variable. All independent variables are packaged in year t, with a one-year lag from the dependent variable. This permits us to check whether ESG disclosure in year t can forecast the crash risk in year $t+1$.

The control variables ($Controls$) are those factors that may affect future crash risk based on previous literature (Kim et al., 2014). We first include the lagged variable of crash risk ($NCSKEW_{i,t}$ or $DUVOL_{i,t}$) for possible serial correlation. Then, we include eight other control variables in the model. Chen et al. (2001) document that, besides trading volume, prior returns can also affect future crash risk because any surging accumulated during past returns is usually followed by a plummet in price. Therefore, we consider past returns (RET), firm size ($SIZE$), and the market-to-book

ratio (MB) as control variables. Since investor opinion heterogeneity has a link to the stock price crash risk (Hong and Stein, 2003), the detrended stock trading volume ($DTURN$), an indicator of investors' strategy set diverseness, is also added. Stock volatility ($Sigma$) is included since volatile stocks are expected to undergo a future price crash in a larger chance. Other firm-level variables, including the absolute value of abnormal accruals ($ABACC$) used for measuring earnings management (Hutton et al., 2009), financial leverage (LEV), and profitability (ROA) are also included as control variables. Table 2.1 shows the variable definitions.

Our empirical analysis regressed the firm-specific crash risk in year t+1 on ESG and other control variables in year t. We considered industry and year fixed effects (*Industry* and *Year* dummies) in our regression. Consistent with the prior literature, we estimate the regression with the standard error modified by a two-dimensional cluster at both firm and year level (Petersen, 2009; Kim et al., 2014). In addition to the panel data regressions, we also consider the endogenous issues which may confuse the accurate relation between ESG and firm-specific crash risk. To lighten the endogenous concerns, we conduct the two-stage instrument variable method (2SLS) with the average ESG of remaining firms in the identical industry as the instrumental variable.

2.6 Empirical results

2.6.1 Descriptive statistics

Table 2.2 and Figure 2.1 show the yearly sample distribution. We can see that the sample size increased rapidly from the year 2008. It may be due to the increased number of companies that choose to publish ESG reports or the expanded coverage of the Bloomberg database. The two gauges of crash risk (NCSKEW and DUVOL) show relative stability across years, except for the highest crash risk in 2008.[16] The

[16]The high value of crash risk in 2008 reflects the financial crisis.

years 2009 and 2016 have the lowest crash risk.[17] The average ESG score keeps increasing over time while the value is relatively small in the first three years. This means the level of ESG information disclosure by Chinese companies is increasing yearly.

We can intuitively see the variations of ESG, NCSKEW, and DUVOL values over the year in Figure 2.2. The blue line represents ESG values and shows an upward trend by year. This means the firms in our sample are increasing ESG disclosure and investment, and their ESG performance is improving yearly. The NCSKEW and DUVOL values fluctuate over time. The low points in the years 2009 and 2016 were encountered right after the stock market crash in the last year, which released a lot of hidden bad news. The values of two stock price crash risk measurements, NCSKEW and DUVOL in red and green, are very close each year.

[Table 2.2]

[Figure 2.1 & 2.2]

Table 2.3 reports the descriptive statistics for the major variables used in our regression models. The average values of two crash risk evaluations $NCSKEW$ and $DUVOL$ are -0.342 and -0.235, respectively. The mean ESG score is 21.881. The mean of detrended average monthly share turnover is 0.042. The mean and standard deviation of firm-specific weekly returns are 0.003 and 0.010, respectively. The firm in our sample has an average book-to-market ratio of 2.133, an average leverage of 0.491, an average return on assets of 0.046, and an average size of 23.095. The mean absolute value of abnormal accruals is 0.053. These data are consistent with the previous literature (Kim et al., 2014).

[Table 2.3]

Table 2.4 presents the correlation matrix for the variables used in our main regression models. Pearson's correlation determines the strength and direction of

[17] The two years are right after the Chinese stock market crash, thus showing lower stock price crash risk.

the linear relationship between two variables. In Table 2.4, the correlation coefficient between *F_NCSKEW* and *F_DUVOL* is 0.876 and statistically significant at the 1% level. It means that the two measures for crash risk are highly significantly correlated with each other and capture similar information, although their constructions are quite different. The Pearson correlation coefficient of ESG and *F_NCSKEW* (*F_DUVOL*) is -0.003 (-0.008).[18] It shows that there is no linear relationship between ESG and crash risk in bivariate analysis. Spearman's rank-order correlation determines the strength and direction of the monotonic relationship between two variables. The Spearman's rank-order correlation coefficient between ESG and *F_NCSKEW* (*F_DUVOL*) is -0.005 (-0.010), which indicates that there is a non-monotonic relationship between the two variables.

[Table 2.4]

Figure 2.3 intuitively shows the relation between ESG disclosure and firm-specific crash risk. We use "F_NCSKEW" to represent a crash risk in the graph above and "F_DUVOL" to represent crash risk in the graph below. The red line in the graphs fits the relationship between ESG and crash risk. We can see a non-monotonic relationship in both pictures though it is not so obvious. The curve is an intuitive confirmation of our hypothesis. In the next section, we explore the relationship statistically.

[Figure 2.3]

2.6.2 Effect of ESG on crash risk

Table 2.5 shows the regression results of the relationship between ESG and crash risk with controlling other probable determining factors of crash risk. From the results in Table 2.5, we can see that the linear relationship in columns (1) and (2) (whether the dependent variable shows as F_NCSKEW or F_DUVOL) is not significant, which means the association between ESG and crash risk is not liner. This finding is inconsistent with many studies that have verified a negative connection between ESG

[18] We put another measure of crash risk and the corresponding Pearson coefficient in parentheses.

and crash risk (Kim et al., 2014; Feng et al., 2021). It is also contradictory to Dai et al. (2019), which proved an inverted U-shaped relationship between CSR and crash risk. The results in columns (3) and (4) in table 2.5 present that the coefficient of the ESG quadratic term is significantly positive and the coefficient of ESG is significantly negative. This means the link between ESG and predicted crash risk(in one year) (represented as F_NCSKEW and F_DUVOL) is non-monotonic. Column (3) indicates that when ESG increases, the crash risk in the next year first decreases and then increases afterward. The critical point appears when the ESG score is about 20.91 (that is when the natural logarithm of ESG score equals about 3.04). Column (4) also indicates the relationship, which first goes down and then up. The critical point in column (2) appears when the ESG score is about 20.70 (that is when the natural logarithm of ESG score equals about 3.03), which is very similar to column (1). Comparably, the mean and median values of the ESG score are 21.88 and 21.07, respectively. Therefore, the critical point is very close to the mean and median values.

As shown in previous studies, in developed countries, the negative relationship shows that the higher the ESG level, the more transparent the company's information, and the lower the risk of stock crashes. However, in developing countries, such as China, ESG development is at an early stage, and the situation is different. Here, the ESG disclosure and regulatory systems are immature. At the same time, due to the country's emphasis on sustainable development, companies are likely to achieve their personal goals by presenting high-level ESG information to the public. Therefore, the higher ESG level here may not mean that the company's information is transparent and the available stakeholder advantages, but it hides serious agency problems, which increases the risk of stock crashes. As to the control variables, *MB* and *Ret* are significantly and positively correlated with crash risk, while Sigma is significantly and negatively related to crash risk. The coefficients of the control variables are consistent with previous studies. (Kim et al., 2014; Dai et al., 2019).

However, the criterion of a significant quadratic term is weak. The problem

arises when the true relationship is convex but monotone over relevant data values. A quadratic specification may then erroneously yield an extreme point.[19] Lind and Mehlum (2010) put forward "utest" (a test in STATA) to provide the exact test of the presence of a turning point on an interval. This test first calculates the location of the extreme point according to the regression equation and then divides the whole data into the data before and after the extreme point. After that, it checks whether the first part of the data is monotonically downward and whether the latter part is monotonically upward. The null hypothesis for this test is "monotone or inverse U-shape". After performing the utest, we obtain the values of the t-value and P-value, 1.56 and 0.0703, respectively. The null hypothesis is rejected at a 10% confidence level. Overall, the results in table 2.5 present that the relationship between ESG and crash risk is non-monotonic, which means an appropriate ESG disclosure, rather than a too-low or too high-ESG score, is most beneficial to maintaining the stock price stable.

[Table 2.5]

2.6.3 Endogeneity

The preliminary result shows a non-monotonic link between ESG and one-year-ahead firm-specific stock price crash risk. However, considering the potential endogeneity problems is necessary. Endogeneity may arise due to unobservable firm-specific factors which affect both ESG and crash risk at the same time. Our estimation model uses the lagged ESG score to predict the following year's crash risk. This could potentially mitigate endogeneity concerns named reverse causality. The simultaneity concern remains since the ESG scores are very sticky over the sample years. Thus, we conduct the instrumental variables method to estimate the model.

[19] Specifically, given that the true relationship of the two variables is monotonically increasing (or monotonically decreasing) when we add a quadratic term to the regression, this may generate an unreal extreme point, presenting a falsely significant quadratic term.

According to the prior research (e.g., (Kim et al., 2014)), we select the average ESG score of the other firms in the same industry as the instrumental variable.[20] This instrumental variable satisfies both relevance and exogenous restrictions: first, the average ESG score of all other firms in the same industry is usually related to this firm's ESG; on the other hand, the ESG of other firms cannot affect the crash risk of this firm. We have performed relevant tests to show that the instrumental variables are appropriate. For the endogeneity test: The P values of the Durbin-Wu-Hausman test were zero, rejecting the null hypothesis that $lnESG$ and $lnESG^2$ are exogenous variables. For the weak instrumental variable test: The first-stage F values are around 362 and 431, indicating that there are significant correlations between instrumental variables and endogenous explanatory variables.[21]

The result of the instrumental variables method is shown in Table 2.6. For the first stage (Columns (1) and (2)), we consider two endogenous variables, namely, $lnESG$ and $lnESG^2$. For this reason, two IVs, $IV\_(lnESG)$ and $IV\_(lnESG^2)$ are used. Here, $IV\_(lnESG)$ is the natural logarithm of average ESG of all other firms in the same industry. For both $lnESG$ equation and $lnESG^2$ equation, we have used both $IV\_(lnESG)$ and $IV\_(lnESG^2)$. We control "Control" for both equations at the first stage. The control variables used in both equations are the same and also the same as those used in the second stage. For the second stage (Columns (3) and (4)), we use two dependent variables, F_NCSKEW and F_DUVOL, for robustness. The first stage results indicate that the instrumental variable is significantly positively related to the $lnESG$ and $lnESG^2$. The third and fourth columns are significant and consistent with the baseline findings. Therefore, the non-monotonic relationship still holds after addressing the endogeneity concerns via the instrumental variable method.

[Table 2.6]

[20] The classification of the industries refers to the "China 2012 Industry Classification Standard" issued in 2012.

[21] Both of the two F values have a P value of zero.

2.6.4 Robustness test

Several robustness tests have been conducted to ensure the results' reliability. First, we use two indicators, $NSKEW$ and $DUVOL$, to measure stock price crash risk, and we find the results consistent between these two in all tables. Second, since ESG contains social responsibility and environmental responsibility, the ESG engagement of dirty industries[22] will have a greater impact on their firm value. Therefore, we divided the research samples into dirty and clean industries to conduct regression. From Table 2.7, we can see that the quadratic relationship between ESG and crash risk exists in dirty industries, but not in other industries. This suggests that ESG can significantly impact company value in industries where ESG engagement is more important like dirty industries. According to the 2012 version of the industry classification of listed companies, we classify B (mining industry), C (manufacturing industry), D (electricity, heat, gas, and water production and supply industry) as dirty industries, and other industries as clean industries.

[Table 2.7]

We divided the samples into manufacturing (generally considered more pollution-carrying) and non-manufacturing industries to conduct regression, respectively, and the results are shown in Table 2.8. From Table 2.8, we can see that the quadratic relation between ESG and crash risk exists in the manufacturing industry but not in other industries. This suggests that ESG can significantly impact company value in industries where ESG engagement is more important, like manufacturing.

[Table 2.8]

Third, we divided the research samples into two parts, whether recent years or not (we took the recent five years as recent years) and presented the results in Table 2.9. As ESG investment is increasingly valued in China, ESG engagement has likely had a more significant impact on firm value in recent years than before. From the results in Table 2.9, we can see that the quadratic correlation between ESG and

[22] We refer to heavy-polluting industries as dirty industries.

crash risk exists only in the sample data after 2015, regardless of whether NSKEW or DUVOL is taken as the dependent variable. This result shows that as the public attaches more importance to ESG (environmental responsibility, social responsibility, corporate governance) engagement in recent years, the company's ESG performance significantly impacts the firm value.

[Table 2.9]

2.7 Conclusion

Sustainable development is becoming more and more important nowadays. As an important part of the economy and society, to improve their competitiveness in the fierce market and achieve sustainable development while pursuing profit, enterprises must actively conduct their ESG engagement. As China has focused more on sustainable development at all levels of the country in recent decades, it is of great significance for Chinese-listed enterprises to fulfill their ESG.

This paper examines the effect of ESG disclosure on firm-specific stock price crash risk. This is a meaningful problem as a business invest a lot in ESG event and wish to earn some benefits from ESG engagement. Previously, there are two mainstream rival claims on this relationship. On one hand, ESG disclosure equals a high degree of transparency in financial reporting, which is found significantly reduce crash risk by previous studies in financial transparency (e.g. Lowenstein, 1996). Thus, ESG is expected to reduce the stock price crash risk (e.g., negatively related). On the other hand, however, ESG disclosure is also viewed as an expectation management tool (moral hazard problem), a sign of hypocrisy of managers who may hide bad news and even grasp benefits for their private interest. In this case, ESG may increase the stock price crash risk (e.g., positively related). Each theory received empirical support from previous research, leading to a controversial pending problem.

This paper tries to solve the problem quantitatively. We first develop an analytical model to cover dominant variables in both theories and establish an important result that the relationship overall is non-monotonic. Specifically, a low ESG level should decrease crash risk while a high ESG level does the contrary. This insight is very useful and solid, yet insufficient to give a specific function form. Therefore, we further use reduced-form analysis to derive a non-monotonic curve. Using the Chinese A-share listed firms during the year 2006-2020 as a sample, we find that there is a non-monotonic relationship between ESG and crash risk and the relationship holds after controlling other impacting factors. In addition, our results remain robust after considering potential endogenous problems using the IV method. This finding means that the discretional exposure of ESG information has a complicated connection with firm-specific stock price crash risk. Specifically, as the firm discloses more ESG information, its stock price crash risk first decreases and increases afterward.

Our study adds to the growing ESG literature in two senses. First, this paper expands the scope of ESG research as we introduce an analytical model instead of pure empirical evidence. This offers us more insight into the mechanism and can bring about counterfactual knowledge. Second, our empirical finding of the non-monotonic curve is novel and robust. Using data from Chinese listed companies, this finding coincides with our analytical result. There are some implications for the manager, investor, policymaker, and other relevant agents. For the manager, it is important to conduct ESG engagement at an appropriate level since it can not only help enhance the firm's reputation but also help keep the stock price stable. For the investor, it is possible to choose firms with appropriate ESG to score rather than too low or too high to invest, to reduce the potential damage that may cause by the stock price crash to personal interests. For the policymaker, making regulations encouraging companies with low ESG scores to disclose more ESG information can help reduce the volatility in the stock market.

This study still has some limitations. First, the ESG score in this study was measured by the evaluation index of the third-party rating agency. Albeit it seems appropriate and is generally accepted by academics, the index still has some deficiency in reflecting the actual ESG performance of listed firms in China. Since the ESG score is attained based on the ESG information disclosed by the firms, the rating agencies have not evaluated the actual ESG performance of the listed firms. The advanced measurement method is necessary to be carried out for more credible results. Second, the sample only contains the listed firm disclosing the ESG information. It is not a high percentage compared to all the listed firms, thus the evaluation index can not fully reflect the ESG performance of all Chinese listed firms. More firms with ESG disclosure will help ease this problem in the future.

Tables

TABLE 2.1: Variable definition

Variables	Definition	Source
Crash risk variables		
NCSKEW	The negative coefficient of skewness. See Eq. (2.25) for details.	Calculated by the authors
DUVOL	The down-to-up volatility. See Eq. (2.26) for details.	Calculated by the authors
Key independent variables		
ESG	ESG score	Bloomberg
Firm-level control variables		
SIZE	measured as the natural log of a firm's total assets	CSMAR
ROA	measured as the income before extraordinary items divided by total assets	CSMAR
MB	measured as the ratio of the firm's market value to the book value	CSMAR
LEV	measured as the total liability scaled by total assets	CSMAR
Sigma	the standard deviation firm-specific weekly return over the fiscal year	Calculated by the authors
Ret	the average firm-specific weekly return over the fiscal year	Wind
DTURN	the detrended stock trading volume, calculated as the average monthly share turnover for the current fiscal year minus the average monthly share turnover for the previous fiscal year	Wind
ABACC	The absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow et al., 1995).	Calculated by the authors

TABLE 2.2: Sample distribution

Year	Frequency	Percent	ESG	NCSKEW	DUVOL
2005	4	0.06	12.293	0.175	0.111
2006	12	0.18	14.910	-0.438	-0.316
2007	28	0.41	15.507	-0.222	-0.116
2008	216	3.19	19.413	-0.039	-0.019
2009	277	4.09	20.652	-0.498	-0.370
2010	297	4.38	21.275	-0.138	-0.122
2011	429	6.33	21.826	-0.229	-0.156
2012	585	8.63	20.766	-0.243	-0.152
2013	642	9.47	20.885	-0.420	-0.270
2014	638	9.41	21.113	-0.426	-0.288
2015	710	10.48	21.584	-0.282	-0.207
2016	671	9.9	22.280	-0.542	-0.382
2017	728	10.74	22.826	-0.190	-0.123
2018	794	11.72	23.363	-0.108	-0.092
2019	746	11.01	23.542	-0.437	-0.299
Total	6777	100	21.881	-0.309	-0.214

Note: This table shows the sample size and mean values of ESG and crash risk measures by year. The sample includes 6777 firm-year observations from 2005 to 2019.

TABLE 2.3: Descriptive statistics

VarName	Obs	Mean	SD	Min	Median	Max
F_NCSKEW	6777	-0.342	0.725	-5.170	-0.296	3.736
F_DUVOL	6777	-0.235	0.481	-2.046	-0.235	2.239
ESG	6777	21.881	5.284	9.091	21.074	61.722
NCSKEW	6777	-0.309	0.721	-5.170	-0.271	3.736
LEV	6777	0.491	0.197	0.008	0.502	1.698
SIZE	6777	23.095	1.266	19.541	23.018	28.341
DTURN	6777	0.042	0.138	-0.746	0.000	0.770
MB	6777	2.133	1.608	0.692	1.631	30.674
ROA	6777	0.046	0.065	-0.902	0.039	0.590
Ret	6777	0.003	0.010	-0.038	0.002	0.075
Sigma	6777	0.059	0.024	0.015	0.054	0.232
ABACC	6777	0.053	0.052	0.000	0.037	0.470

Note: This table reports the descriptive statistics of all variables. The data ranges from 2005 to 2019 for ESG and control variables and from 2006 to 2020 for crash risks.

TABLE 2.4: Pearson correlation matrix

	F_NCSKEW	F_DUVOL	ESG	NCSKEW	DUVOL	LEV	SIZE	DTURN	MB	ROA	Ret	Sigma	ABACC
F_NCSKEW	1												
F_DUVOL	0.876***	1											
ESG	-0.003	-0.008	1										
NCSKEW	0.072***	0.070***	0.001	1									
DUVOL	0.064***	0.060***	-0.007	0.878***	1								
LEV	-0.066***	-0.076***	0.089***	-0.080***	-0.089***	1							
SIZE	-0.059***	-0.082***	0.364***	-0.074***	-0.097***	0.493***	1						
DTURN	0.005	0.009	-0.048***	0.038***	0.035***	-0.032***	-0.059***	1					
MB	0.151***	0.148***	-0.145***	0.095***	0.085***	-0.450***	-0.445***	0.044***	1				
ROA	0.117***	0.111***	-0.007	0.109***	0.100***	-0.474***	-0.106***	0.058***	0.436***	1			
Ret	0.068***	0.058***	-0.042***	-0.168***	-0.186***	-0.024**	-0.089***	0.018	0.375***	0.117***	1		
Sigma	-0.067***	-0.077***	-0.135***	-0.088***	-0.086***	0.039***	-0.219***	0.003	0.264***	-0.100***	0.394***	1	
ABACC	0.016	0.014	-0.073***	0.025**	0.012	0.053***	-0.063***	-0.014	0.084***	0.012	0.003	0.095***	1 height

Note: This table reports the correlation coefficients of each variable in our main regression. All correlation coefficients are below 0.8 (except the correlation coefficients of similar measures), indicating no significant multi-collinearity problem exists. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 2.5: Regression analysis on the effect of ESG on crash risk

	(1) F_NCSKEW	(2) F_DUVOL	(3) F_NCSKEW	(4) F_DUVOL
$lnESG$	0.024	0.019	-0.845**	-0.632*
	(0.86)	(0.80)	(-2.27)	(-1.98)
$lnESG^2$			0.139**	0.104*
			(2.47)	(2.11)
NCSKEW	0.059*		0.059*	
	(1.93)		(1.93)	
DUVOL		0.046**		0.046**
		(2.66)		(2.63)
LEV	0.018	0.012	0.018	0.012
	(0.25)	(0.24)	(0.25)	(0.24)
SIZE	0.007	-0.005	0.006	-0.006
	(0.26)	(-0.29)	(0.24)	(-0.32)
DTURN	-0.025	-0.005	-0.027	-0.006
	(-0.36)	(-0.13)	(-0.39)	(-0.16)
MB	0.052***	0.033***	0.051***	0.033***
	(6.01)	(5.09)	(5.98)	(5.06)
ROA	0.164	0.072	0.163	0.071
	(0.73)	(0.44)	(0.73)	(0.43)
Ret	9.733***	6.448***	9.720***	6.438***
	(3.70)	(3.40)	(3.70)	(3.39)
Sigma	-0.714	-0.847*	-0.722	-0.853*
	(-0.82)	(-1.81)	(-0.83)	(-1.81)
AbsDA	-0.018	-0.019	-0.022	-0.022
	(-0.16)	(-0.20)	(-0.19)	(-0.24)
Constant	-0.352	0.081	0.974	1.075*
	(-0.58)	(0.18)	(1.61)	(1.98)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777
adj. R^2	0.091	0.090	0.091	0.090
F	2659.527	3145.522	106.443	157.664

Note: This table reports regression results of the impact of ESG scores on the probability of firm-level stock crash risk. The sample covers 6777 firm-year panel observations from 2006 to 2019. Notice that the two-tailed t-values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 2.6: Regression analysis to address endogeneity concerns

	(1)	(2)	(3)	(4)
	First1	First2	Second1	Second2
Dep. Var.	$lnESG$	$lnESG^2$	F_NCSKEW	F_DUVOL
$IV\_(lnESG)$	0.164***	-6.497***		
	(4.04)	(-3.72)		
$IV\_(lnESG^2)$	-0.044	2.032***		
	(-0.17)	(7.24)		
$(lnESG)\_HAT$			-6.305*	-4.551*
			(-1.69)	(-1.79)
$(lnESG^2)\_HAT$			1.050*	0.750*
			(1.74)	(1.83)
NCSKEW			0.056***	
			(4.39)	
DUVOL				0.043***
				(3.34)
LEV	-0.095***	-0.597***	0.043	0.025
	(-2.99)	(-3.11)	(0.65)	(0.55)
SIZE	0.061***	0.388***	-0.014	-0.018
	(9.71)	(8.97)	(-0.89)	(-1.64)
DTURN	-0.030	-0.178	-0.029	-0.009
	(-1.26)	(-1.22)	(-0.45)	(-0.21)
MB	-0.007**	-0.043**	0.051***	0.032***
	(-2.77)	(-2.68)	(5.92)	(5.47)
ROA	-0.068	-0.420	0.161	0.070
	(-1.35)	(-1.36)	(0.81)	(0.51)
Ret	1.632***	10.309***	9.152***	6.113***
	(4.45)	(4.49)	(5.85)	(5.72)
Sigma	-0.479***	-2.949**	-0.679	-0.838*
	(-2.98)	(-2.91)	(-1.06)	(-1.92)
AbsDA	-0.067	-0.396	-0.031	-0.031
	(-1.51)	(-1.46)	(-0.18)	(-0.27)
Constant	0.404	2.252	9.371	7.089*
	(1.35)	(1.11)	(1.64)	(1.82)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777
F	362	431		

Note: This table shows the regression result after dealing with endogeneity issues on the effect of ESG scores on crash risk. Columns (1) and (2) present the first-stage results of the instrumental variable method, and columns (3) and (4) report the second-stage results of the instrumental variable method. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses.. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 2.7: Regression analysis: dirty vs clean industries

	(1)	(2)	(3)	(4)
	F_NCSKEW		F_DUVOL	
	clean	dirty	clean	dirty
$lnESG$	-1.075	-0.732	-0.320	-0.694*
	(-1.12)	(-1.72)	(-0.51)	(-1.99)
$lnESG^2$	0.166	0.123*	0.049	0.115**
	(1.07)	(1.93)	(0.46)	(2.17)
NCSKEW	0.081*	0.047		
	(1.84)	(1.70)		
DUVOL			0.051	0.042**
			(1.38)	(2.49)
LEV	0.295**	-0.073	0.213***	-0.053
	(2.95)	(-0.76)	(2.98)	(-0.95)
SIZE	-0.006	0.011	-0.017	-0.001
	(-0.23)	(0.37)	(-1.01)	(-0.07)
DTURN	0.070	-0.067	0.039	-0.024
	(1.35)	(-0.68)	(0.95)	(-0.50)
MB	0.069***	0.046***	0.042***	0.030***
	(3.50)	(6.67)	(3.24)	(5.63)
ROA	0.289	0.135	0.305	0.003
	(1.07)	(0.57)	(1.02)	(0.01)
Ret	10.826**	9.288***	7.268***	6.094**
	(2.97)	(3.40)	(3.60)	(2.96)
Sigma	-0.418	-0.992	-0.762	-0.986**
	(-0.27)	(-0.97)	(-0.74)	(-2.68)
AbsDA	-0.127	0.006	-0.046	-0.021
	(-0.57)	(0.04)	(-0.22)	(-0.17)
Constant	1.259	0.647	0.578	1.006
	(1.19)	(1.08)	(0.89)	(1.40)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	1980	4797	1980	4797
adj. R^2	0.093	0.096	0.090	0.097
F	510.366	317.316	2111.252	1078.668

Note: This table shows the regression result of the effect of ESG on crash risk in dirty and clean industries. Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 2.8: Regression analysis: manufacture vs other industries

	(1) F_NCSKEW	(2)	(3) F_DUVOL	(4)
	others	manufacture	others	manufacture
$lnESG$	-0.718	-0.909*	-0.394	-0.782*
	(-0.81)	(-1.81)	(-0.52)	(-1.83)
$lnESG^2$	0.118	0.148*	0.067	0.127*
	(0.80)	(1.99)	(0.52)	(1.95)
NCSKEW	0.064	0.055*		
	(1.49)	(2.12)		
DUVOL			0.045	0.046**
			(1.38)	(2.75)
LEV	0.161**	-0.059	0.110**	-0.037
	(2.19)	(-0.52)	(2.21)	(-0.62)
SIZE	0.003	0.009	-0.008	-0.005
	(0.11)	(0.31)	(-0.41)	(-0.26)
DTURN	-0.016	-0.034	-0.023	0.002
	(-0.17)	(-0.42)	(-0.31)	(0.05)
MB	0.078***	0.042***	0.046***	0.028***
	(3.78)	(7.04)	(3.56)	(5.44)
ROA	0.095	0.202	0.113	0.054
	(0.37)	(0.84)	(0.51)	(0.30)
Ret	11.128***	9.011***	6.839***	6.238***
	(3.35)	(3.69)	(3.46)	(3.39)
Sigma	-1.464	-0.315	-1.329*	-0.614
	(-1.58)	(-0.22)	(-2.02)	(-1.01)
AbsDA	-0.032	-0.017	0.016	-0.041
	(-0.13)	(-0.10)	(0.08)	(-0.39)
Constant	0.962	0.596	0.766	1.095
	(0.85)	(0.57)	(0.81)	(1.27)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	2698	4079	2698	4079
adj. R^2	0.083	0.102	0.078	0.106
F	666.117	2226.738	694.626	1125.902

Note: This table shows the regression result of the effect of ESG scores on crash risk in different industries (manufacture or not). Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 2.9: Regression analysis: recent vs previous years

	(1) F_NCSKEW previous	(2) recent	(3) F_DUVOL previous	(4) recent
$lnESG$	0.204	-1.072*	0.264	-0.924***
	(0.23)	(-2.16)	(0.31)	(-7.32)
$lnESG^2$	-0.029	0.163*	-0.039	0.143***
	(-0.19)	(2.23)	(-0.26)	(6.81)
NCSKEW	0.063**	0.039		
	(2.79)	(0.88)		
DUVOL			0.049*	0.028
			(2.19)	(1.71)
LEV	0.061	-0.014	0.003	0.028
	(0.71)	(-0.13)	(0.05)	(0.41)
SIZE	-0.036	0.061***	-0.030	0.026*
	(-1.21)	(5.99)	(-1.32)	(2.42)
DTURN	-0.075	0.032	-0.008	-0.008
	(-0.74)	(0.38)	(-0.14)	(-0.10)
MB	0.044**	0.062***	0.029**	0.040***
	(2.91)	(19.34)	(2.78)	(39.72)
ROA	0.705***	-0.172*	0.441**	-0.189*
	(4.61)	(-2.63)	(2.81)	(-2.67)
Ret	8.486*	9.644**	5.581	6.946**
	(1.85)	(3.71)	(1.66)	(4.05)
Sigma	0.310	-0.869	0.012	-1.119
	(0.25)	(-0.66)	(0.02)	(-1.64)
AbsDA	-0.100	0.009	-0.054	-0.016
	(-0.88)	(0.05)	(-0.57)	(-0.09)
Constant	0.359	0.739	0.286	1.432***
	(0.35)	(1.97)	(0.30)	(6.50)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	3128	3649	3128	3649
adj. R^2	0.114	0.101	0.112	0.100
F	789.283	43.355	2014.699	54.619

Note: This table shows the regression result of the effect of ESG scores on crash risk in different years (recent years from 2015-2019 or not). Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Figures

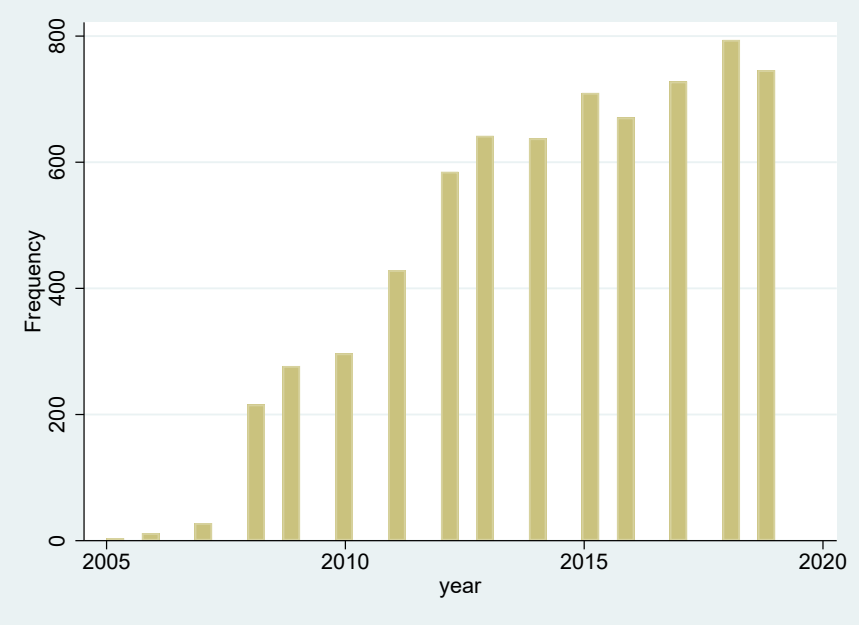

FIGURE 2.1: The number of firms with ESG disclosure in each year

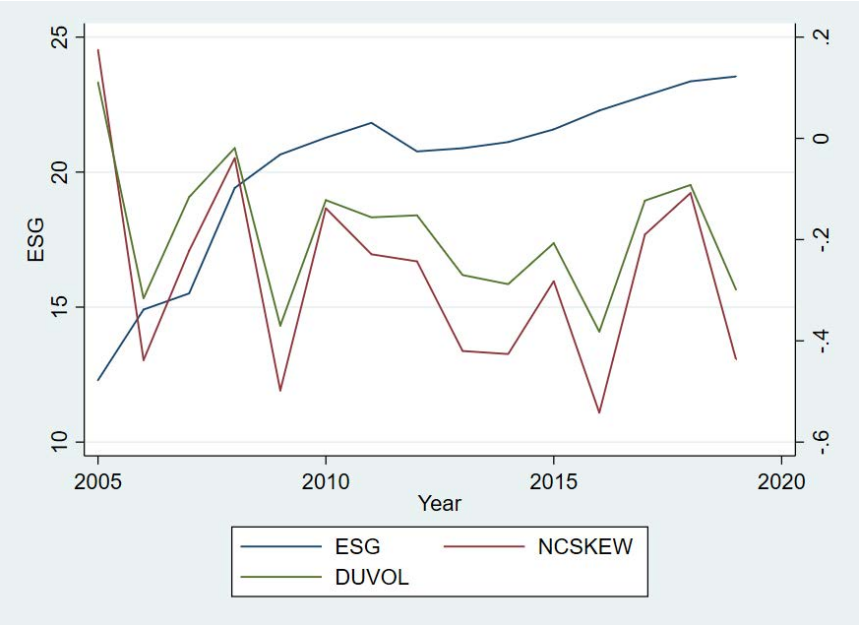

FIGURE 2.2: The values of ESG, NCSKEW, and DUVOL over the year

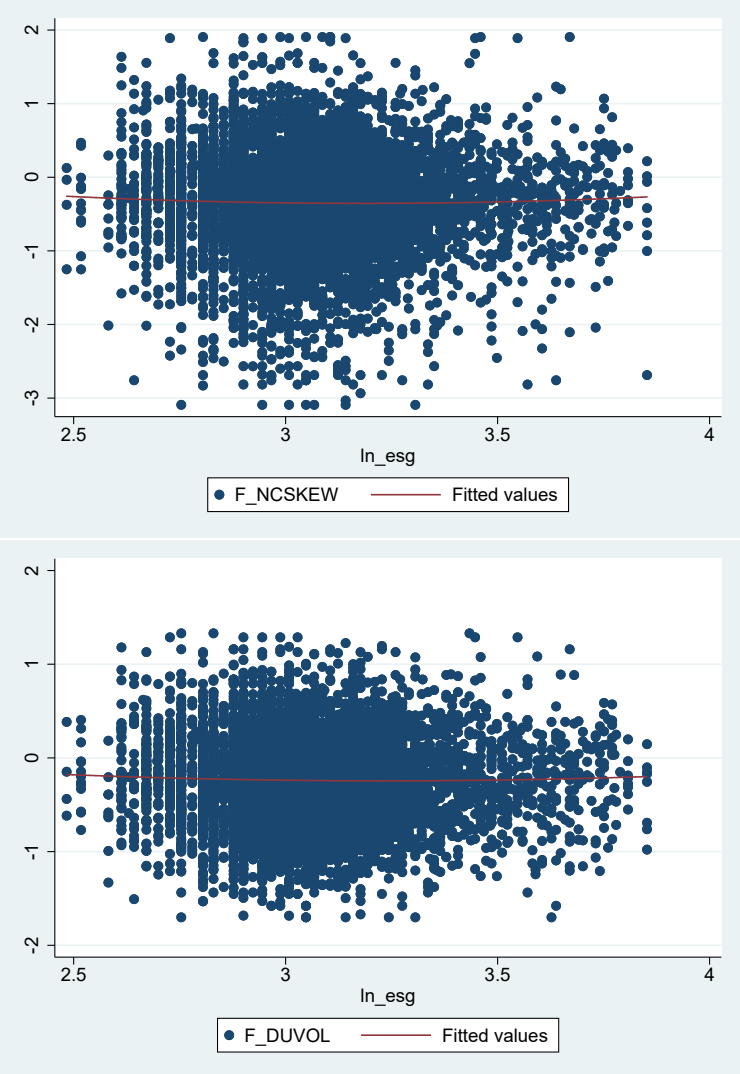

FIGURE 2.3: The relationship between ESG disclosure and crash risk

Chapter 3

ESG, Innovation, and Firm Performance: Evidence from China

3.1 Introduction

Over the past few decades, more people[1] focus on corporate sustainable practices and have put increasing pressure on companies to create social value. At the same time, research on corporate sustainability engagement raises fundamental questions about the association between corporate social responsibility (CSR) and firm performance (FP) (Hasan et al., 2018; Callan and Thomas, 2009). Consistently, the Environmental, Social, and Governance Engagement (ESG) score is one of the most common metrics for measuring a company's sustainable performance and has been widely used by consultancies, asset managers, and researchers to determine a company's sustainable practices (Gillan et al., 2021).

As an essential part of sustainable development strategy, ESG is irreplaceable for improving corporate reputation and achieving corporate sustainable development. Integrating CSR into the company's business decision-making process has many benefits for the development of the company, such as effectively improving the company's competitiveness, improving the company's reputation, exploring market potentials, and achieving sustainable profitability (Hao et al., 2018). Excellent enterprises can not only tap social needs to create profits, but also vigorously perform their duties and repay society, so as to realize the positive interaction between the economic value of the enterprise and the social value, and promote the sustainable development of enterprises and society (Derwall et al., 2011).

Some studies view ESG as a company's investment of risk hedging strategy (Feng et al., 2021), or enhancement of company value (Servaes and Tamayo, 2013) and productivity (Hasan et al., 2018). Jiao (2010) explains how the positive impact of CSR on corporate performance is consistent with the view that CSR represents an investment in intangible assets (such as reputation), which contributes to the competitiveness of enterprises. There is also some research arguing that ESG is a tool used by managers to pursue private interests, which can lead to serious agency

[1] See Banerjee et al. (2019) and Rahman et al. (2022) as examples.

problems that can damage a company's value. Plenty of studies[2] have investigated the relationship between ESG and firm performance, but little has studied the factors that may influence the relationship of ESG and total factor productivity (TFP) and the mediating factors of this relationship. Therefore, this paper aims to study the relationship between ESG and firm efficiency and to explore the moderators that can influence this relationship and the mediators that can explain this relationship.

This study has three main contributions to the existing literature: First, in terms of measuring the firm performance, most of the previous literature[3] only uses single-dimensional indicators, such as ROA and Tobin's Q, but we use a multi-dimensional enterprise's TFP which considers multiple productive factors (total output, labor input, capital input, and product cost) to improve the credibility of the results. Second, the strength of the association between ESG and TFP may be affected by other factors. Some factors may serve as mediators, which can be potential mechanisms by which an independent variable (here ESG) can produce changes on a dependent variable (here TFP). To fill the gap in previous research, we consider both moderating and mediating roles of innovation in the ESG-FP relationship. Third, we set China as the research background. Compared with developed countries, ESG development here is still in its infancy, and the public's awareness of ESG is low, so the relationships may be different.

In this study, we use the data of the Chinese A-share listed enterprises from 2005 to 2019 for empirical analysis. The results show a significantly positive relationship between ESG and firm productivity (TFP). There is also a significantly positive relationship between each single dimension and TFP. The results suggest that companies with better ESG performance have higher productivity. Our finding is consistent with shareholder theory that companies with better ESG performance have higher reputations, higher market competitiveness, and thus higher productivity. When

[2]See Ruan and Liu (2021) and Huang (2021) as examples.
[3]See Bahadori et al. (2021) and Shaikh (2022) as examples.

examining the role of innovation in the ESG-TFP relationship, we found that innovation has a moderating role. That is to say, the company's innovation level will significantly affect the ESG-TFP relationship, and under different innovation levels, ESG-TFP presents different relationships. In addition, innovation is also partially mediating role; that is, innovation explains part of the relationship between ESG and TFP. ESG leads to higher productivity by increasing the level of innovation in companies.

The rest of this chapter is arranged as follows: The next section is the literature review and hypothesis formulation. In section 3.3, we introduce variables, data, and empirical methods. Section 3.4 shows the main results. Section 3.5 presents the robustness tests. Section 3.6 concludes the paper.

3.2 Literature review and hypothesis development

3.2.1 ESG and firm performance

Two views prevail in the literature regarding the relationship between corporate sustainability and financial performance (FP). In the light of the Porter hypotheses (Porter and Linde, 1995), corporate social responsibility (CSR) engagement could help trigger innovation activities, creating additional profits to offset the relevant costs. Therefore, a suitable CSR design can help to improve CFP. The legitimacy theory viewpoint argues that ESG disclosure aims to gain social legitimacy for environmental or social impacts caused by the firm's operation (Lokuwaduge and Heenetigala, 2017). Stakeholder theory states that CER could yield satisfactory prestige among stakeholders, such as employees, suppliers, and government departments. This enhances the corporate value and market competitiveness (Dixon-Fowler et al., 2017). Many studies have found a positive linkage between ESG and FP (Fatemi et al., 2015; Wang and Sarkis, 2017).

On the contrary, the trade-off hypothesis argues that the consideration of ESG issues in firm decisions weakens the financial performance of a firm because the

economic benefits of such activities are less than their costs (Trumpp and Guenther, 2017). For example, enhancing CER may divert resources from the corporate core business and hence generate relative disadvantages compared with rivals that are not as environmentally responsible. Agency theory claims that management often uses CSR as a self-interest tool to enhance personal reputation, thereby neglecting shareholder interests and reducing firm value (Hao et al., 2018). CSR activities bring additional costs caused by agency problems and inefficient resource allocation, which will put the firm in an unfavorable position in the free and competitive market (Xie et al., 2019). Some previous studies have argued a negative linkage between ESG and FP (Branco and Rodrigues, 2008). Except for positive and negative relationships, the neutral and nonlinear ones have also been found in some relevant literature (Horváthová, 2010; Xie et al., 2019).

H1a: Firms' ESG score and its individual pillars positively affect firms' firm performance (TFP).

H1b: Firms' ESG score and its individual pillars negatively affect firms' firm performance (TFP).

3.2.2 ESG and innovation

Wijethilake et al. (2018) contend that active ESG tactics should be combined with the corporate invention to drive corporate sustainability efforts to make sense. Song and Yu (2018) find that the aggressive environmental schemes boosted enterprises' innovative abilities. Yang et al. (2019) show that market and social pressures faced by managers promote their focus on positive ESG strategies, which then stimulate the advancement of innovation capabilities. Soto-Acosta et al. (2018) mention that the environmental management ability of enterprises is positively correlated with the level of innovation. And innovation is able to ease growing stress from stakeholders for green commodities. Kawai et al. (2018), with the help of stakeholder theory, point out that stakeholder force is conducive to enhancing a firm's innovation level.

3.2.3 Innovation and firm performance

Corporate innovation is vital in helping companies achieve long-term success in a competitive marketplace (Al Naqbia et al., 2020). Plenty of previous literature claims that firm innovation is intrinsically associated with higher effectiveness (Pedersen et al., 2018). Enterprise innovation can bring product, service, or supply chain differentiation, such as new functions, low cost, etc., so as to improve the overall competitiveness of the company. Compared with enterprises with insufficient innovation, enterprises with high innovation ability can adjust more flexibly to the continuously changing market, keep a competitive state, and improve enterprise value. Corporate innovation is a powerful tool that new firms could use to exceed established firms as well as established companies that need to maintain a competitive position in the changing market (Doran and Ryan, 2016). Rajapathirana and Hui (2018) argue that corporate innovation is generally recognized as a core element for triumphing in a highly competing economy and global markets.

3.2.4 ESG, innovation and firm performance

Existing literature indicates an insufficient comprehension of how ESG investments enhance corporate financial performance via innovation. Aguinis and Glavas (2019), based upon ample research, show an evident gap in the usage of various approaches to study CSR initiatives and the factors that may influence the association between CSR and company value. Consequently, we require to explore the mechanisms and moderators between ESG and firm performance. Enterprise innovation is critical for enterprises to implement ESG and enhance enterprise value. It is also an essential factor that may influence the ESG effect. With the increasing demand for sustainable development and the complexness of client needs, CER can help companies deliver consumers high-grade goods and services, build good relations with suppliers and clients, and generate more environmentally friendly merchandise via innovation (Provasnek et al., 2017; Chuang and Huang, 2018). Li et al. (2020) find

that innovation could mediate the relation between CER and corporate value. Innovation affects the impact of ESG on company performance and is also deemed a critical element in achieving ESG. Therefore, we regard corporate innovation as a moderator and mediator when investigating the association between ESG engagement and corporate performance. This could help us obtain more valid results and better understand this relationship.

We thereby propose the following main hypothesis.

H2: Innovation plays a significant moderating role in the relationship between ESG and firm performance (TFP).

H3: Innovation plays a significant mediating role in the relationship between ESG and firm performance (TFP).

3.3 Research design

3.3.1 Data and sample

Our sample contains the data of A-share firms listed on the Shanghai and Shenzhen exchanges from 2005 to 2019. The data for 2020 are not included, because of the deviation caused by the epidemic, which started in January 2020 and has had a great negative impact on the world's economies. In order to ensure the validity of the data and eliminate the influence of abnormal values on the empirical test, we deal with the data as follows: 1. Excluding financial companies; 2. Excluding ST, *ST companies[4] in the sample; 3. Drop missing values; and 4. Continuous variables are winsorized at the 1st and 99th percentiles.[5]

ESG scores are collected from Bloomberg Professional Service. Other data used in this study are gathered from China Stock Market & Accounting Research Database (CSMAR). Our final sample contains 660 firms and 2583 firm-year observations from 2005 to 2019. The specific data sources for each variable are presented in Table 3.1.

[4]These companies are at risk of delisting.
[5]This is to avoid the effect of extreme values on the results.

[Table 3.1]

3.3.2 Measurement of total factor productivity

In this paper, we measure company performance using the firm's TFP. TFP is typically obtained as a residual of a Cobb-Douglas production function with capital, labor, and materials as input factors and value-added as output (Hasan et al., 2018). TFP can be estimated by employing parametric and non-parametric techniques. The non-parametric approach is widely considered to be more robust to endogeneity problems. For example, parametric methods may suffer from reverse causality of inputs and high correlations with productivity components, which can be addressed by semi-parametric methods (Tsionas and Polemis, 2019). Two semi-parametric methods, the LP and OP methods[6], proposed by Levinsohn and Petrin (2003) and Olley and Pakes (1996) respectively, are the most widely used techniques to measure TFP. Therefore, we use LP and OP methods to measure our core dependent variable, the enterprise's TFP.

Following previous literature (Hasan et al., 2018), we obtain both TFP measures as the residuals of the OP and LP production functions where the total output is represented by the company's annual operating income; labor input is expressed by the number of employees; capital input is expressed by net fixed assets; intermediate input is expressed by the company's operating costs plus the company's sales expenses, management expenses, and financial expenses minus the contemporaneous depreciation and amortization and cash paid for employees. Figure 3.1 shows the means of TFP for the two calculation methods in each year during the sample interval. The table shows that the TFP values in each year calculated by the two methods are consistent. The descriptive statistics of estimated average TFP levels are reported in Table 3.2.

[Figure 3.1]

[6]The OP method is short of the Olley-Pakes method and the LP method is the short of Levinsohn-Petrin method. OP and LP methods are explained in Appendix A and Appendix B respectively.

[Table 3.2]

3.3.3 ESG measurement

We use ESG scores obtained from the Bloomberg Professional Services platform. Its ESG information is primarily gathered from corporate sustainability reports, financial reports, and firms' news and announcements. The ESG disclosure score measures the transparency of ESG information, and the scoring process takes into account disparities in importance and industry distinctions for each data point. Bloomberg's ESG data varies from 0.1 to 100, with the two extremes representing the minimum level of disclosure and disclosure of all relevant information, respectively (Siew, 2015).

The ESG score consists of the company's sustainable behaviors. The Environmental (E) dimension reflects the company's efforts to sustainably use resources, emissions, and innovation to reduce customers' environmental footprints. The Social (S) dimension focuses on human capital (job satisfaction, workplace health, safety, diversity, equity). Finally, Governance (G) dimension aims to better corporate governance, treat shareholders equally, and incorporate non-financial objectives into strategic and management decisions. Here, we expect aggregate and individual ESG scores to correlate positively with the firm's TFP. The descriptive statistics of ESG scores are reported in Table 3.2.

3.3.4 Innovation measurement

The company's innovation input means the value of resources invested in innovation activities (Levinsohn and Petrin, 2003). Referring to Jiang (2020), this study uses R&D expenditures to evaluate corporate innovation input. In the regression model, R&D expenses are in natural logarithmic form.

We assume that innovation mediates and moderates the relationship between ESG and TFP. Based on previous literature (Yang et al., 2021), we use R&D investment and the number of granted patents to measure a company's level of innovation. Among them, R&D investment is measured by R&DSum (R&D investment amount (million)) and in the model, we take the natural logarithm of R&DSum. In addition, China's granted patents are divided into three types according to the degree of innovation: invention, utility model, and design. Here we choose the number of granted invention patents (Grants) as the other measure of innovation level since invention patents are more innovative than two other patents. Using different innovative metrics, the robustness of the results can be enhanced, making the results more reliable.

3.3.5 Control variables

Following prior studies (Danquah et al., 2014; Tang et al., 2020), we choose variables that may be factors affecting TFP as our control variables. Davis et al. (2014) indicate that a firm's productivity is correlated with the firm size since small- and large-sized firms organize their production processes differently. Tsai and Luan (2016) claim that the financial conditions of firms influence current firm performance and contribute to long-term enterprise growth through the growth of overall productivity. Geylani and Stefanou (2013) state that older companies show higher productivity since they are more experienced and less exposed to newness. Levine and Warusawitharana (2021) find out that firms can use their cash reserves to invest in activities that enhance firm competitiveness, and firms with higher cash holdings would face a lower likelihood of default if they were to access external debt markets. Shen et al. (2012) state that because of the server agency problem, SOEs are more likely to have low efficiency. Syverson (2011) contends that high-growth firms outperform their rivals with the ability to exploit their previous investments in successful innovation, thus having higher productivity. Cai and Ye (2020) show that companies with high fixed asset ratios are more likely to have the problem of inefficient use of resources. Thus

their productivity is more likely to be lower than other companies in the same industry. Wu et al. (2022) find a significant and positive relationship between ROA and corporate efficiency.

Therefore, we choose the following control variables: Size, measured as logarithm of total assets; Lev, measured as total liabilities/total assets; Fixedratio, measured as net fixed assets/total assets; Age, measured as current year-enterprise listing year; Cashflow, measured as net cash flow generated from operating activities/total assets; Growth, measured as revenue growth rate; ROA, measured as net profits/total average assets. SOE is a dummy variable, SOE equals one if the enterprise is state-owned; otherwise, zero. The variable definitions and corresponding data sources are listed in Table 3.1.

3.3.6 Empirical model

First, based on hypotheses H1a and H1b, in order to investigate how ESG is associated with firm performance, we estimated the following model:

$$FP_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \alpha' \text{ Controls }_{i,t} + \alpha_2 \text{ Industry } + \alpha_3 \text{ Year } + \varepsilon_{i,t} \tag{3.1}$$

where the dependent variable, firm performance, is measured by firm-specific TFP. The primary independent variable ESG is proxied by ESG (total ESG score), E (environmental score), S (social score), and G (governance score). Controls are variables that potentially influence TFP, like firm size, leverage, etc. We also control industry (*Industry*) and year (*Year*) fixed effects in the model.

Secondly, to test hypothesis H2, we use the following model to investigate whether innovation level plays a moderating role in the relation between ESG and TFP.

$$\begin{aligned} FP_{i,t} = {} & \omega_0 + \omega_1 ESG_{i,t} + \omega_2 \text{ Innovation }_{i,t} + \omega_3 ESG_{i,t} * \text{ Innovation }_{i,t} \\ & + \omega' \text{ Controls }_{i,t} + \omega_4 \text{ Industry } + \omega_5 \text{ Year } + \varepsilon_{i,t} \end{aligned} \tag{3.2}$$

Here, we add the variable of innovation and interaction term of ESG and innovation (ESG*innovation). And the interaction term is used to investigate innovation' moderating effect on the connection of ESG and TFP. If ω_3 is significant, innovation plays a significant moderating effect.

Thirdly, in terms of hypothesis H3, we exploit the following models to test whether innovation plays a mediating role in the ESG-TFP relationship:

$$\text{Innovation}_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta' \text{ Controls}_{i,t} + \beta_2 \text{ Industry} + \beta_3 \text{ Year} + \varepsilon_{i,t} \quad (3.3)$$

$$\begin{aligned} FP_{i,t} = {} & \sigma_0 + \sigma_1 ESG_{i,t} + \sigma_2 \text{ Innovation}_{i,t} + \sigma' \text{ Controls}_{i,t} + \sigma_3 \text{ Industry} \\ & + \sigma_4 \text{ Year} + \varepsilon_{i,t} \end{aligned} \quad (3.4)$$

Model (3.3) is created to analyze the effect of ESG on firm innovation. Model (3.4) is formed to detect the impact of ESG and firm innovation on firm performance. Controls in (3.3) and (3.4) are variables that potentially influence innovation and TFP, respectively.

According to previous studies, the most commonly used method to test the mediation impact is to assess regression coefficients step by step. Thus, we also use this method to examine the mediating role of innovation. The first step is to test the coefficient α_1. Stop the mediation effect analysis if the coefficient α_1 is not significant. If it is significant, go to the second step; in this step, we inspect the coefficients β_1 and σ_2; if both of them are significant, come to the third step; in the third step, check the coefficient σ_1. A significant σ_1 means a partial mediation effect exists. An insignificant σ_1 means that it is a completely mediating effect. In the fourth step, if at least one of the coefficients β_1 and σ_2 is insignificant, perform the Sobel test.[7] If the Sobel test results are significant, the mediation effect exists. If the results are insignificant, the mediation effect does not exist (Li et al., 2020).

[7]Since both coefficients β_1 and σ_2 are significant, it is unnecessary to perform the Sobel test. Thus, we have not conducted this test in the paper.

The relationships among ESG, innovation, and total factor productivity are represented as a path diagram in Figure 3.2.

[Figure 3.2]

3.4 Empirical results

3.4.1 Descriptive statistics

The descriptive summary of the variables is listed in Table 3.2. The mean values of TFP measures (i.e., TFP_LP and TFP_OP) were 9.630 and 6.865, respectively. The standard deviations of the two variables are 1.029 and 0.798, respectively. The significant SD indicates that the TFP of different companies in China varies widely. The average ESG score of the sample companies is 22.232 (the E, S, and G scores are 10.953, 25.338, and 44.937, respectively). In this dataset, the companies have an average R&D investment of 286.997 million per year. The average R&D investment ratio is 3.925%, and the average number of granted invention patents is 18.940. The average firm size is 22.848. The mean leverage is 0.458. The average return on assets (ROA) is 0.052, and the mean cash flow is 0.056. The average listed age of the companies is 2.275 years. The mean of sales growth is 0.158. The average fixed assets ratio is 0.238. 44.1% of firms in the sample are state-owned.

Table 3.3 displays the correlation matrix of variables employed in the empirical study. From this table, we can see that there is no serious multicollinearity in the model. The correlation coefficients between ESG and TFP_LP, ESG and TFP_OP[8] are significantly positive at the level of 1%, which preliminarily affirmed the accuracy of hypothesis H1a. Nonetheless, multivariate regression is still required to investigate these relationships. In addition, the correlation coefficient of TFP_LP and TFP_OP is 0.94, which is significant at the 1% significance level. This shows that the TFP values obtained by the two calculation methods are very consistent.

[8]TFP_LP represents the company's TFP calculated using the LP method and TFP_OP means the company's TFP calculated using the OP method.

[Table 3.3]

3.4.2 The relationship between ESG and TFP

We first drew scatterplots of ESG (and the three pillars) and TFP and added fitted lines to show their relationships. Figures 3-6 show the scatter plots and fitted lines between ESG-TFP, E-TFP, S-TFP, and G-TFP, respectively. From those figures, we can see a positive relationship between the company's ESG level and productivity. The higher the company's ESG score, the higher the production efficiency. Similarly, their three pillars (E, S, and G) show an apparent positive linear relationship with productivity. The higher the three sub-scores, the higher the company's productivity. On this basis, we then use multivariate regression to explore this relationship more scientifically.

[Figures 3.3, 3.4, 3.5 & 3.6]

Table 3.4 shows the combined and individual effects of E, S, and G factors on two TFP proxies (TFP_LP and TFP_OP) estimated using Equation (3.1) in the sample period. The results show that the total ESG score is significantly positively related to TFP (whether measured by TFP_LP or TFP_OP). The individual ESG components' results are similar and always point to positive and significant associations with TFP. Our findings are consistent with previous research showing a positive relationship between a firm's CSR and TFP (Hasan et al., 2018). The positive impacts of ESG and its components on corporate TFP are consistent with the stakeholder theory proposed in the first hypothesis (H1a). The coefficients of the control variables are also consistent with previous studies (Cai and Ye, 2020).

[Table 3.4]

3.4.3 Moderating effect of innovation on the relationship between ESG and TFP

Table 3.5 reports the test results of the moderating effect of innovation level. The test aims to investigate whether the relationship between ESG scores and TFP varies with the level of innovation. As mentioned in the H2 reasoning process, the company's investment in ESG is more likely to reflect suboptimal resource allocation among companies with high innovation capability. When a company's innovation level increases, the investment in innovation will be more efficient, while the limited resources invested in ESG may weaken the company's productivity.

In order to test this hypothesis, we employed two approaches. First, we re-run the regression model in equation (3.1) after dividing our sample into two according to innovation's median value. The results are reported in columns (1)-(2) and (4)-(5) of Table 3.5. We find that ESG is more significant and positively correlated with the TFP (TFP_LP and TFP_OP) when firms have lower innovation levels. Second, we re-run the regression analysis by adding the interaction term of ESG* innovation to the equation (3.2). The results are shown in columns (3) and (6) of Table 3.5. We saw that the coefficient of the interaction term (ESG* innovation) is significantly negatively correlated with TFP_LP and TFP_OP, although the value is minimal. The coefficient of the interaction term between ESG and innovation is negative, indicating that the positive correlation between ESG and TFP is stronger when the innovation level is lower. This result is consistent with that of the first method. Using the two methods, we know that innovation significantly moderates the relationship between ESG and TFP (TFP_LP and TFP_OP).

For convenience, we put the regression results of the three ESG individual dimensions in Table 3.6. The results of the moderating effect of corporate innovation for E, S, and G are consistent with the total ESG score. The magnitude and significance of the coefficients of control variables are similar to the ESG regressions. Thus, we omit the reporting of the control variables for brevity.

[Tables 3.5 & 3.6]

3.4.4 Mediating effect of innovation on the relationship between ESG and TFP

Table 3.7 shows the mediation effect of innovation on the ESG-TFP relationship. For the first step, columns (1) and (4) of Table 3.7 are the same as the results in Table 3.4, which means that ESG is significantly positively correlated with TFP. The second step, columns (2) and (5), shows that ESG is significantly positively correlated with innovation, which means that listed companies with higher ESG scores have higher innovation levels. For the third step, columns (3) and (6) show the correlation coefficient and significance level between ESG and TFP, adding the mediator innovation. Innovation is significantly positively correlated with TFP_LP and TFP_OP. In the same regression model, ESG was also significantly positively correlated with TFP, with correlation coefficients of 0.005 and 0.004, respectively. Therefore, based on the step-by-step testing method, we determine that innovation partially mediates between ESG and TFP (TFP_LP and TFP_OP). Therefore, innovation plays an important partial mediating role between ESG scores and TFP. The results support the H2 hypothesis that ESG enhances TFP by increasing the innovation level. For convenience, we put the regression results of the three ESG individual dimensions in Table 3.8. The results of individual environmental and governance dimensions are consistent with that of total ESG scores. For the social dimension, since the coefficients of ESG in columns (3) and (6) are not significate, the impact of ESG on TFP can be completely explained by innovation. Thus, innovation plays a completely mediating effect on the social-TFP relationship.

[Table 3.7 & 3.8]

3.5 Robustness check

3.5.1 Endogeneity concerns

To mitigate endogeneity concerns caused by omitting related explanatory variables, we conduct the instrumental variables (IV) method (Two-Stage Least Squares (2SLS) regression). Following prior studies, like El Ghoul et al. (2011) and Kim et al. (2014), we use the average ESG_SCORE of other firms in the same industry as the instrumental variables. This instrumental variable satisfies both relevance and exogenous restrictions: first, the average ESG score of all other firms in the same industry is usually related to the firm's ESG; on the other hand, the ESG of other firms cannot affect the TFP of the firm. We have performed relevant tests to show that the instrumental variable is appropriate. For the endogeneity test: the P value of the Durbin-Wu-Hausman test was 0, rejecting the null hypothesis that ESG is an exogenous variable. For the weak instrumental variable test: the first-stage F value is 26.22, indicating that there is a significant correlation between the instrumental variable and endogenous explanatory variable. Table 3.9 shows the 2SLS regression results of the ESG-TFP relationship. Column (1) shows the results of the first stage. Columns (2) and (3) show the results of the second stage with TFP_LP and TFP_OP as dependent variables, respectively. From Table 3.9, we can see that 2SLS regression results are consistent with our baseline finding, which means that ESG is significantly positively correlated with TFP after addressing the endogeneity problem.

Instrumental variables selection and rationale for three ESG individual dimensions (E, S, and G) are similar to those for ESG. For convenience, we put the 2SLS regression results of them in one table, Table 3.10. The 2SLS regression results of all three individual dimensions are consistent with that of total ESG scores and baseline findings.

[Tables 3.9 & 3.10]

3.5.2 Excluding some sample periods

Since the amount of ESG data collected from Bloomberg was very low in previous years, there were fewer than 60 observations per year before 2011 in our sample. To reduce the sample bias caused to our results, we excluded the research samples before 2011 in the robustness test. The results are shown in Table 3.11. From the table, the results are consistent with our baseline findings.

[Table 3.11]

3.5.3 Measure corporate innovation by number of patents

In addition to R&D investment, the number of authorized invention patents also reflects the company's innovation level. Much of the previous literature has used patent counts to measure firm innovation (e.g., Li et al. (2020)). Therefore, to increase the robustness of the results, we also use the number of patents to represent firm innovation and explore the moderating and mediating effect of innovation in the relationship between ESG and TFP.

Table 3.12 shows the moderating effect of innovation on ESG-TFP when the number of patents is used to measure the level of innovation. Columns (1)-(2) and (4)-(5) are grouped regression results, and columns (3) and (6) are regression results with interaction terms. The subgroups' regression results show that innovation level can significantly moderate the impact of ESG on TFP. However, the moderating effect is not presented in the regression results with interaction terms. When the level of corporate innovation is low, the positive impact of ESG on TFP is more significant. When the level of corporate innovation is high, the positive effect is smaller or insignificant. The grouped regression results are consistent with our baseline findings.

[Table 3.12]

Table 3.13 shows the regression results of mediating effects of innovation on ESG-TFP when the number of patents is used to measure innovation level. Columns (2)

and (5) present a significantly positive relation between ESG and corporate innovation, which means that ESG could boost innovation. In columns (3) and (6), the coefficients of ESG and lnGrants are significantly positive. This shows that in the relationship between ESG and TFP, the level of corporate innovation plays a partial intermediary role. That is to say, the promotion of ESG to TFP is partly achieved by improving corporate innovation. The regression results of the mediation effect of using the number of patents to measure the level of enterprise innovation are consistent with the baseline findings.

[Table 3.13]

3.6 Conclusion

Sustainable development is an essential part of scientific development and is widely concerned by society and academia. The sustainable development of an enterprise means actively fulfilling corporate social and environmental responsibilities while pursuing profits. Currently, the Chinese listed companies are paying more and more attention to ESG information disclosure, and the number of companies that disclose ESG information is increasing yearly. A firm's TFP reflects how efficiently a firm converts input resources into outputs. For the same resource input, companies with high TFP can bring more profits and have stronger competitiveness in the fierce market. It is, therefore, crucial to explore whether a company's ESG performance is conducive to improving company productivity. At the same time, there is also an urgent need to study how differences in companies' innovation capabilities affect the relationship between ESG and TFP.

With a sample of the Chinese listed companies from 2005 to 2019, this study explores the impact of ESG (and its subdimensions) on firms' TFP and the role of innovation in this relationship. The research results show that: (1) the total ESG score and its sub-dimensions (environmental, social, and governance) have a significantly positive relationship with the company's TFP. That is, the company's ESG

performance is conducive to improving production efficiency, thereby improving its competitiveness in the market. To alleviate the impact of endogeneity, we used the instrumental variable method, and the results were still consistent. To make the results more robust, we removed the years with a small amount of data and changed the way the variables were measured, and the results were still the same. (2) The mechanism test found that the company's innovation level partially mediates the ESG-TFP relationship. The promotion of ESG to TFP is partly achieved by improving the company's innovation level. The mediating effect of innovation also exists in the relationship between three sub-dimensions and TFP. (3) Finally, we find that the level of firm innovation can moderate the relationship between ESG and TFP. Specifically, in companies with relatively low innovation, the promotion effect of ESG on TFP is more obvious.

In theory, this research supplements ESG-related studies, enriching the understanding of the economic consequences of corporate ESG performance. Our findings also complement the literature on factors influencing firms' TFP. Combining corporate ESG investment as a corporate development strategy with corporate innovation capabilities, our research explores their joint impact on corporate TFP and contributes to a better understanding of the relationship between corporate responsible investment and corporate efficiency. In reality, the conclusions of this study provide a reference for the Chinese corporate managers, investors, and relevant government departments to evaluate the effectiveness of corporate ESG investment and innovation and also provide a method for corporate managers to improve corporate efficiency. The relevant research results of this study have an important reference value for the decision-making of investors, managers, and relevant government departments in developing countries similar to China. Specifically, suppose corporate managers can pay attention to social and environmental responsibility and improve relationships with employees, investors, consumers, etc. while pursuing profits. In that case, corporate ESG investment can enhance the company's brand image and

also improve the company's efficiency. This effect is greater in enterprises which are lack innovation. Investors can select companies with higher ESG scores for investment because companies with high production efficiency can use resources more efficiently and be more competitive in the market. Government policymakers should formulate relevant policies to encourage enterprises to invest in ESG, especially less innovative companies, and to improve the company's efficiency.

Tables

TABLE 3.1: Variable description

Variable	Description	Source
TFP_LP	Total factor productivity derived from Levinsohn and Petrin (2003) method	Calculated by the authors
TFP_OP	Total factor productivity derived from Olley and Pakes (1996) method	Calculated by the authors
ESG	Total ESG score	Bloomberg
E	Firm's environmental performance score	Bloomberg
S	Firm's Social performance score	Bloomberg
G	Firm's Governance performance score	Bloomberg
R&DSum	R&D investment amount (million)	CSMAR
Grants	Number of granted invention patents	CSMAR
Size	Logarithm of total assets	CSMAR
Lev	Operating leverage multiplied by financial leverage	CSMAR
Fixedratio	Net fixed assets/total assets	CSMAR
Age	Current year-enterprise listing year	CSMAR
Cashflow	Net cash flow from operating activities/total assets	CSMAR
SOE	Dummy variable, SOE = 1 if the enterprise is state-owned, otherwise, SOE = 0	CSMAR
Growth	Revenue growth rate	CSMAR
ROA	Net profits/total average assets	CSMAR

TABLE 3.2: Descriptive statistics

VarName	Obs	Mean	SD	Min	Median	Max
Dependent variables						
TFP_LP	2583	9.630	1.029	6.785	9.553	12.456
TFP_OP	2583	6.865	0.798	4.547	6.793	9.427
Core independent variables						
ESG	2583	22.232	5.597	9.091	21.074	58.852
E	2583	10.953	6.713	1.550	9.302	57.292
S	2583	25.338	8.514	3.509	22.807	73.684
G	2583	44.937	5.199	28.571	44.643	62.500
Moderating and mediating variables - innovation						
RDSum	2583	286.997	442.724	0.326	114.085	2476.935
Grants	2583	18.940	104.349	0.000	3.000	2537.000
Control variables						
Size	2583	22.848	1.207	19.552	22.768	26.105
Lev	2583	0.458	0.194	0.035	0.464	0.925
ROA	2583	0.052	0.060	-0.175	0.043	0.238
Cashflow	2583	0.056	0.067	-0.196	0.051	0.257
Growth	2583	0.158	0.381	-0.588	0.106	4.806
SOE	2583	0.441	0.497	0.000	0.000	1.000
ListAge	2583	2.275	0.633	0.693	2.398	3.258
Fixedratio	2583	0.238	0.152	0.002	0.204	0.725

Note: This table shows the sample size and descriptive statistics of all variables. The sample includes 2583 firm-year observations from 2005 to 2019.

TABLE 3.3: Pearson correlation matrix

	TFP_LP	TFP_OP	ESG	E	S	G	RDSum	Grants	Size	Lev	ROA	Cashflow	Growth	SOE	ListAge	Fixedratio
TFP_LP	1															
TFP_OP	0.940***	1														
ESG	0.341***	0.299***	1													
E	0.316***	0.277***	0.924***	1												
S	0.215***	0.196***	0.794***	0.570***	1											
G	0.290***	0.244***	0.574***	0.374***	0.334***	1										
RDSum	0.616***	0.528***	0.307***	0.286***	0.223***	0.207***	1									
Grants	0.269***	0.208***	0.102***	0.094***	0.060***	0.097***	0.436***	1								
Size	0.849***	0.731***	0.366***	0.340***	0.230***	0.306***	0.606***	0.265***	1							
Lev	0.487***	0.442***	0.154***	0.141***	0.062***	0.189***	0.292***	0.118***	0.547***	1						
ROA	0.036*	0.046**	-0.013	-0.028	0.049**	-0.064***	-0.009	0.003	-0.115***	-0.512***	1					
Cashflow	0.061***	0.043**	0.008	0.014	0.013	-0.017	-0.014	0.010	-0.036*	-0.262***	0.521***	1				
Growth	0.072***	0.103***	-0.017	-0.029	0.017	-0.025	-0.000	-0.020	0.010	0.010	0.242***	0.056***	1			
SOE	0.265***	0.244***	0.162***	0.161***	0.094***	0.119***	0.147***	0.016	0.328***	0.273***	-0.265***	-0.110***	-0.098***	1		
ListAge	0.352***	0.304***	0.197***	0.168***	0.102***	0.244***	0.207***	0.062***	0.414***	0.337***	-0.237***	-0.034*	-0.091***	0.394***	1	
Fixedratio	-0.039**	-0.103***	0.044**	0.093***	-0.041**	0.007	-0.087***	-0.052***	0.105***	0.151***	-0.244***	0.169***	-0.098***	0.130***	0.153***	1

Note: This table reports the correlation coefficients of each variable in our main regression. All correlation coefficients are below 0.8 (except the correlation coefficients of similar measures), indicating no significant multi-collinearity problem exists. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.4: Regression analysis on the effect of ESG on TFP

	TFP_LP				TFP_OP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG	0.007***				0.005***			
	(3.51)				(2.62)			
E		0.006***				0.005***		
		(3.75)				(3.15)		
S			0.002*				0.001	
			(1.74)				(1.20)	
G				0.006***				0.003
				(2.74)				(1.23)
Size	0.666***	0.665***	0.674***	0.672***	0.416***	0.414***	0.422***	0.422***
	(56.58)	(56.79)	(58.74)	(58.35)	(35.50)	(35.43)	(36.77)	(36.34)
Lev	0.812***	0.815***	0.807***	0.792***	0.680***	0.684***	0.676***	0.668***
	(10.34)	(10.38)	(10.20)	(10.04)	(8.45)	(8.49)	(8.36)	(8.25)
ROA	2.218***	2.222***	2.213***	2.246***	1.533***	1.536***	1.529***	1.546***
	(8.63)	(8.65)	(8.61)	(8.72)	(5.84)	(5.85)	(5.82)	(5.87)
Cashflow	1.504***	1.503***	1.509***	1.499***	1.201***	1.199***	1.204***	1.199***
	(7.63)	(7.64)	(7.61)	(7.58)	(5.76)	(5.77)	(5.76)	(5.74)
Growth	0.077***	0.077***	0.074***	0.076***	0.115***	0.116***	0.113***	0.114***
	(3.00)	(3.03)	(2.88)	(2.99)	(3.95)	(3.99)	(3.86)	(3.89)
SOE	0.042*	0.041*	0.045**	0.048**	0.088***	0.086***	0.090***	0.092***
	(1.92)	(1.87)	(2.05)	(2.20)	(4.01)	(3.95)	(4.11)	(4.21)
ListAge	0.040**	0.043**	0.042**	0.036*	0.017	0.019	0.019	0.016
	(2.21)	(2.37)	(2.34)	(1.95)	(0.90)	(1.01)	(1.00)	(0.85)
Fixedratio	-0.684***	-0.698***	-0.681***	-0.673***	-0.790***	-0.801***	-0.787***	-0.786***
	(-8.72)	(-8.93)	(-8.61)	(-8.46)	(-10.39)	(-10.57)	(-10.28)	(-10.22)
Constant	-6.700***	-6.616***	-6.807***	-6.956***	-3.514***	-3.426***	-3.594***	-3.675***
	(-28.54)	(-27.69)	(-29.33)	(-30.52)	(-15.58)	(-14.96)	(-16.11)	(-16.49)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583	2583	2583
adj. R^2	0.793	0.794	0.792	0.793	0.636	0.637	0.635	0.635
F	284.326	284.718	282.703	283.430	130.020	130.349	129.528	129.531

Note: This table reports regression analysis on the impact of ESG scores on TFP. The sample includes 2583 firm-year observations from 2005 to 2019. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.5: Moderating effect of innovation on the ESG - TFP link

	TFP_LP			TFP_OP		
	RDSum>= Median	RDSum< Median	Interaction	RDSum>= Median	RDSum< Median	Interaction
ESG	0.002	0.017***	0.014***	0.000	0.015***	0.011***
	(0.97)	(5.33)	(6.15)	(0.19)	(4.96)	(4.58)
RDSum			0.001***			0.001***
			(9.69)			(6.49)
ESG*RDSum			-0.000***			-0.000***
			(-7.35)			(-4.97)
Size	0.608***	0.631***	0.586***	0.370***	0.416***	0.369***
	(35.62)	(29.58)	(38.46)	(20.02)	(20.78)	(24.58)
Lev	0.866***	0.742***	0.845***	0.827***	0.545***	0.698***
	(8.30)	(6.40)	(10.81)	(7.29)	(4.68)	(8.64)
ROA	2.485***	1.642***	2.145***	1.953***	0.959***	1.475***
	(7.08)	(4.47)	(8.50)	(5.30)	(2.61)	(5.65)
Cashflow	1.151***	1.573***	1.399***	0.851***	1.405***	1.141***
	(4.11)	(5.87)	(7.28)	(2.80)	(4.87)	(5.52)
Growth	0.021	0.131***	0.089***	0.044	0.175***	0.122***
	(0.58)	(3.76)	(3.51)	(1.06)	(4.63)	(4.18)
SOE	0.046*	0.025	0.038*	0.103***	0.047	0.084***
	(1.76)	(0.71)	(1.80)	(3.65)	(1.38)	(3.88)
ListAge	0.089***	0.005	0.037**	0.053**	-0.002	0.014
	(3.59)	(0.17)	(2.04)	(2.01)	(-0.08)	(0.74)
Fixedratio	-0.692***	-0.584***	-0.589***	-0.705***	-0.827***	-0.733***
	(-6.50)	(-5.01)	(-7.73)	(-6.58)	(-7.37)	(-9.58)
Constant	-3.890***	-5.930***	-5.064***	-1.500***	-3.460***	-2.564***
	(-8.06)	(-13.78)	(-16.20)	(-2.83)	(-8.56)	(-8.47)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1292	1291	2583	1292	1291	2583
adj. R^2	0.747	0.726	0.804	0.561	0.564	0.643
F	132.138	98.447	286.453	57.820	48.676	126.584

Note: This table shows the moderating effect of innovation on the ESG - TFP link. Columns (1)-(2) and (4)-(5) are the regression results of the sub-samples (divided by median innovation), and columns (3) and (6) are the regression results with the addition of interaction terms. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.6: Moderating effect of innovation on the ESG individual dimensions - TFP link

Panel A: For E dimension						
	TFP_LP			TFP_OP		
	RDSum>= Median	RDSum<Median	Interaction	RDSum>= Median	RDSum<Median	Interaction
E	0.003**	0.013***	0.012***	0.002	0.012***	0.010***
	(2.02)	(4.74)	(6.49)	(1.23)	(4.35)	(4.98)
RDSum			0.001***			0.000***
			(10.44)			(6.36)
E*RDSum			-0.000***			-0.000***
			(-6.42)			(-4.37)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1292	1291	2583	1292	1291	2583
adj. R^2	0.747	0.724	0.803	0.561	0.563	0.643
F	132.524	97.893	285.692	57.938	48.529	126.452
Panel B: For S dimension						
	TFP_LP			TFP_OP		
	RDSum>= Median	RDSum<Median	Interaction	RDSum>= Median	RDSum<Median	Interaction
S	-0.000	0.005***	0.004***	-0.001	0.005***	0.003**
	(-0.07)	(2.62)	(3.09)	(-0.90)	(2.65)	(2.35)
RDSum			0.001***			0.000***
			(8.28)			(5.23)
S*RDSum			-0.000***			-0.000***
			(-4.58)			(-3.28)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1292	1291	2583	1292	1291	2583
adj. R^2	0.746	0.721	0.801	0.561	0.559	0.640
F	131.957	96.263	281.606	57.881	47.742	125.222
Panel C: For G dimension						
	TFP_LP			TFP_OP		
	RDSum>= Median	RDSum<Median	Interaction	RDSum>= Median	RDSum<Median	Interaction
G	-0.001	0.016***	0.014***	-0.002	0.011***	0.009***
	(-0.29)	(5.19)	(5.94)	(-0.81)	(3.44)	(3.85)
RDSum			0.001***			0.001***
			(8.81)			(6.46)
G*RDSum			-0.000***			-0.000***
			(-7.31)			(-5.66)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1292	1291	2583	1292	1291	2583
adj. R^2	0.746	0.725	0.804	0.561	0.561	0.643
F	131.968	98.366	286.736	57.870	48.061	126.873

Note: This table shows the moderating effect of innovation on the ESG individual dimensions (E, S, G)- TFP link. Columns (1)-(2) and (4)-(5) are the regression results of the sub-samples (divided by median innovation), and columns (3) and (6) are the regression results with the addition of interaction terms. For convenience, we put the results of three individual dimensions (Panel A, B, and C for E, S, and G, respectively) in one table. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.7: Mediating effect of innovation on the ESG - TFP link

	(1) TFP_LP	(2) RDSum	(3) TFP_LP	(4) TFP_OP	(5) RDSum	(6) TFP_OP
ESG	0.007***	8.282***	0.005**	0.005***	8.282***	0.004*
	(3.51)	(5.26)	(2.36)	(2.62)	(5.26)	(1.96)
RDSum			0.000***			0.000***
			(8.87)			(4.96)
Size	0.666***	256.106***	0.598***	0.416***	256.106***	0.378***
	(56.58)	(23.46)	(39.24)	(35.50)	(23.46)	(25.29)
Lev	0.812***	-145.860***	0.851***	0.680***	-145.860***	0.702***
	(10.34)	(-3.36)	(10.83)	(8.45)	(-3.36)	(8.69)
ROA	2.218***	-77.225	2.239***	1.533***	-77.225	1.544***
	(8.63)	(-0.51)	(8.83)	(5.84)	(-0.51)	(5.91)
Cashflow	1.504***	404.878***	1.398***	1.201***	404.878***	1.141***
	(7.63)	(3.69)	(7.22)	(5.76)	(3.69)	(5.49)
Growth	0.077***	-42.125***	0.088***	0.115***	-42.125***	0.121***
	(3.00)	(-2.69)	(3.49)	(3.95)	(-2.69)	(4.16)
SOE	0.042*	-22.639	0.048**	0.088***	-22.639	0.091***
	(1.92)	(-1.48)	(2.22)	(4.01)	(-1.48)	(4.18)
ListAge	0.040**	-20.401*	0.045**	0.017	-20.401*	0.020
	(2.21)	(-1.79)	(2.49)	(0.90)	(-1.79)	(1.05)
Fixedratio	-0.684***	-290.491***	-0.608***	-0.790***	-290.491***	-0.747***
	(-8.72)	(-5.25)	(-7.89)	(-10.39)	(-5.25)	(-9.79)
Constant	-6.700***	-5.6e+03***	-5.225***	-3.514***	-5.6e+03***	-2.682***
	(-28.54)	(-25.19)	(-16.61)	(-15.58)	(-25.19)	(-8.85)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583
adj. R^2	0.793	0.497	0.800	0.636	0.497	0.639
F	284.326	73.951	287.508	130.020	73.951	128.225

Note: This table shows the mediating Effect of innovation on the ESG - TFP link. Columns (1)-(3) are the regression results of TFP measured by TFP_LP, and columns (4)-(6) are the regression results of TFP measured by TFP_OP. For convenience, we put the results of ESG and three individual dimensions (E, S, G) in one table. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.8: Mediating effect of innovation on the ESG individual dimensions (E, S, G) - TFP link

Panel A: For E dimension						
	TFP_LP	RDSum	TFP_LP	TFP_OP	RDSum	TFP_OP
E	0.006***	5.886***	0.005***	0.005***	5.886***	0.004***
	(3.75)	(4.95)	(2.77)	(3.15)	(4.95)	(2.59)
RDSum			0.000***			0.000***
			(8.88)			(4.89)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583
adj. R^2	0.794	0.495	0.800	0.637	0.495	0.640
F	284.718	73.292	287.932	130.349	73.292	128.521
Panel B: For S dimension						
	TFP_LP	RDSum	TFP_LP	TFP_OP	RDSum	TFP_OP
S	0.002*	4.606***	0.001	0.001	4.606***	0.001
	(1.74)	(4.54)	(0.61)	(1.20)	(4.54)	(0.59)
RDSum			0.000***			0.000***
			(9.20)			(5.22)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583
adj. R^2	0.792	0.495	0.799	0.635	0.495	0.639
F	282.703	73.381	286.591	129.528	73.381	127.909
Panel C: For G dimension						
	TFP_LP	RDSum	TFP_LP	TFP_OP	RDSum	TFP_OP
G	0.006***	4.203***	0.005**	0.003	4.203***	0.002
	(2.74)	(2.65)	(2.25)	(1.23)	(2.65)	(0.92)
RDSum			0.000***			0.000***
			(9.13)			(5.23)
Controls	YES	YES	YES	YES	YES	YES
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583
adj. R^2	0.793	0.490	0.800	0.635	0.490	0.639
F	283.430	71.880	287.291	129.531	71.880	127.946

Note: This table shows the mediating Effect of innovation on the ESG individual dimensions (E, S, G)- TFP link. Columns (1)-(3) are the regression results of TFP measured by TFP_LP, and columns (4)-(6) are the regression results of TFP measured by TFP_OP. For convenience, we put the results of three ESG individual dimensions (Panel A, B, and C for E, S, and G, respectively) in one table. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.9: Endogeneity: instrumental variable regression-ESG

	(1)	(2)	(3)
	First stage	Second stage	
Dep. var	ESG	TFP_LP	TFP_OP
IV_ESG	0.409***		
	(3.21)		
ESG_HAT		0.022***	0.014***
		(3.63)	(2.68)
Size	1.580***	0.641***	0.401***
	(12.30)	(42.74)	(27.59)
Lev	-1.741**	0.838***	0.697***
	(-2.41)	(10.68)	(8.66)
ROA	1.600	2.210***	1.527***
	(0.65)	(8.57)	(5.84)
Cashflow	0.434	1.496***	1.196***
	(0.23)	(7.58)	(5.77)
Growth	-0.462*	0.084***	0.120***
	(-1.77)	(3.22)	(4.10)
SOE	0.522**	0.031	0.081***
	(2.31)	(1.40)	(3.67)
ListAge	0.526**	0.033*	0.013
	(2.52)	(1.81)	(0.68)
Fixedratio	0.049	-0.677***	-0.785***
	(0.06)	(-8.69)	(-10.41)
Constant	-30.871***	-6.369***	-3.309***
	(-9.12)	(-23.59)	(-12.91)
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	2581	2581	2581
F	26.22		

Note: This table reports the instrumental variable regression results of TFP on the ESG scores. The sample includes 2581 firm-year observations from 2005 to 2019. IV_ESG is the instrumental variable for the ESG score. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.10: Endogeneity: instrumental variable regression-E, S, G

Panel A: For E dimension			
	First stage	Second stage	
	E	TFP_LP	TFP_OP
IV_E	0.254**		
	(1.97)		
E_HAT		0.017***	0.011***
		(3.78)	(2.68)
Controls	YES	YES	YES
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	2581	2581	2581
F	21.120		
Panel B: For S dimension			
	First stage	Second stage	
	S	TFP_LP	TFP_OP
IV_S	0.616***		
	(5.40)		
S_HAT		0.011***	0.009***
		(2.98)	(2.80)
Controls	YES	YES	YES
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	2581	2581	2581
F	12.045		
Panel C: For G dimension			
	First stage	Second stage	
	G	TFP_LP	TFP_OP
IV_G	0.671***		
	(8.26)		
G_HAT		0.013*	0.008
		(1.93)	(1.24)
Controls	YES	YES	YES
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	2581	2581	2581
F	33.036		

Note: This table reports the instrumental variable regression results of TFP on the ESG individual dimensions (Panel A, B, and C for E, S, and G, respectively). The sample includes 2581 firm-year observations from 2005 to 2019. IV_E, IV_S, and IV_G are the instrumental variables for E, S, and G scores. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.11: Excluding sample periods before 2011

	TFP_LP				TFP_OP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG	0.007***				0.005***			
	(3.53)				(2.73)			
E		0.006***				0.005***		
		(3.66)				(3.10)		
S			0.002*				0.002	
			(1.85)				(1.41)	
G				0.006***				0.003
				(3.00)				(1.60)
Size	0.668***	0.668***	0.676***	0.674***	0.417***	0.416***	0.423***	0.423***
	(55.66)	(55.98)	(57.77)	(57.22)	(35.25)	(35.23)	(36.53)	(36.04)
Lev	0.791***	0.793***	0.785***	0.769***	0.671***	0.674***	0.667***	0.656***
	(9.85)	(9.88)	(9.71)	(9.54)	(8.19)	(8.22)	(8.10)	(7.97)
ROA	2.159***	2.162***	2.155***	2.193***	1.495***	1.497***	1.491***	1.515***
	(8.23)	(8.24)	(8.21)	(8.34)	(5.64)	(5.65)	(5.62)	(5.69)
Cashflow	1.590***	1.590***	1.594***	1.585***	1.243***	1.242***	1.246***	1.241***
	(7.83)	(7.84)	(7.81)	(7.79)	(5.80)	(5.81)	(5.80)	(5.79)
Growth	0.078***	0.078***	0.075***	0.078***	0.116***	0.116***	0.113***	0.115***
	(3.03)	(3.05)	(2.90)	(3.03)	(3.91)	(3.94)	(3.82)	(3.87)
SOE	0.040*	0.039*	0.043**	0.046**	0.081***	0.080***	0.084***	0.086***
	(1.84)	(1.81)	(1.98)	(2.13)	(3.71)	(3.66)	(3.81)	(3.93)
ListAge	0.034*	0.037**	0.036**	0.029	0.013	0.016	0.015	0.011
	(1.85)	(2.02)	(1.99)	(1.56)	(0.70)	(0.81)	(0.80)	(0.60)
Fixedratio	-0.696***	-0.710***	-0.691***	-0.682***	-0.779***	-0.791***	-0.775***	-0.772***
	(-8.84)	(-9.05)	(-8.71)	(-8.53)	(-10.32)	(-10.51)	(-10.19)	(-10.11)
Constant	-6.539***	-6.449***	-6.627***	-6.783***	-3.523***	-3.436***	-3.589***	-3.681***
	(-26.16)	(-25.39)	(-26.71)	(-27.55)	(-14.58)	(-14.03)	(-14.95)	(-15.21)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2479	2479	2479	2479	2479	2479	2479	2479
adj. R^2	0.790	0.790	0.789	0.790	0.629	0.630	0.628	0.628
F	311.599	311.898	309.763	310.811	141.168	141.453	140.595	140.648

Note: This table reports the regression results of TFP on the ESG scores when excluding sample periods before 2011. The sample includes 2479 firm-year observations from 2012 to 2019. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.12: Moderating effect: represent innovation using patents

	TFP_LP			TFP_OP		
	lnGrants>= Median	lnGrants< Median	Interaction	lnGrants>= Median	lnGrants< Median	Interaction
ESG	0.004*	0.012***	0.008***	0.004	0.009**	0.005
	(1.73)	(3.34)	(2.69)	(1.59)	(2.35)	(1.61)
lnGrants			0.039			-0.010
			(1.46)			(-0.37)
ESG*lnGrants			-0.001			0.000
			(-0.86)			(0.10)
Size	0.651***	0.676***	0.658***	0.406***	0.435***	0.419***
	(43.45)	(33.21)	(53.01)	(27.11)	(22.15)	(34.05)
Lev	0.805***	0.860***	0.818***	0.673***	0.723***	0.678***
	(8.18)	(6.89)	(10.40)	(6.42)	(5.86)	(8.40)
ROA	1.827***	2.683***	2.189***	1.293***	1.981***	1.542***
	(5.42)	(6.66)	(8.50)	(3.79)	(4.89)	(5.86)
Cashflow	1.569***	1.393***	1.494***	1.142***	1.253***	1.206***
	(5.34)	(5.04)	(7.55)	(3.96)	(4.10)	(5.78)
Growth	0.062*	0.100**	0.078***	0.090**	0.143***	0.115***
	(1.78)	(2.56)	(3.05)	(2.33)	(3.38)	(3.93)
SOE	0.030	0.042	0.039*	0.103***	0.067*	0.088***
	(1.21)	(1.08)	(1.81)	(3.97)	(1.74)	(4.03)
ListAge	0.088***	-0.009	0.039**	0.036	0.002	0.017
	(3.95)	(-0.29)	(2.17)	(1.54)	(0.06)	(0.90)
Fixedratio	-0.784***	-0.596***	-0.667***	-0.823***	-0.818***	-0.796***
	(-7.95)	(-4.76)	(-8.57)	(-8.30)	(-6.87)	(-10.48)
Constant	-6.069***	-6.847***	-6.554***	-3.179***	-3.913***	-3.582***
	(-18.46)	(-16.67)	(-25.66)	(-6.68)	(-10.09)	(-14.52)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	1474	1109	2583	1474	1109	2583
adj. R^2	0.817	0.747	0.794	0.663	0.590	0.636
F	211.207	120.905	292.942	92.529	59.187	132.280

Note: This table shows the moderating effect of innovation on the ESG - TFP link. Columns (1)-(3) are the regression results of TFP measured by TFP_LP, and columns (4)-(6) are the regression results of TFP measured by TFP_OP. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

TABLE 3.13: Mediating effect: represent innovation using patents

	(1) TFP_LP	(2) lnGrants	(3) TFP_LP	(4) TFP_OP	(5) lnGrants	(6) TFP_OP
ESG	0.007***	0.020***	0.007***	0.005***	0.020***	0.005***
	(3.51)	(4.15)	(3.32)	(2.62)	(4.15)	(2.66)
lnGrants			0.018**			-0.007
			(2.23)			(-0.89)
Size	0.666***	0.429***	0.658***	0.416***	0.429***	0.419***
	(56.58)	(13.69)	(53.10)	(35.50)	(13.69)	(34.09)
Lev	0.812***	-0.354**	0.819***	0.680***	-0.354**	0.678***
	(10.34)	(-1.99)	(10.40)	(8.45)	(-1.99)	(8.40)
ROA	2.218***	1.107*	2.199***	1.533***	1.107*	1.541***
	(8.63)	(1.82)	(8.55)	(5.84)	(1.82)	(5.87)
Cashflow	1.504***	0.807*	1.490***	1.201***	0.807*	1.207***
	(7.63)	(1.85)	(7.53)	(5.76)	(1.85)	(5.79)
Growth	0.077***	-0.086	0.078***	0.115***	-0.086	0.115***
	(3.00)	(-1.49)	(3.05)	(3.95)	(-1.49)	(3.93)
SOE	0.042*	0.057	0.041*	0.088***	0.057	0.088***
	(1.92)	(0.97)	(1.88)	(4.01)	(0.97)	(4.04)
ListAge	0.040**	0.002	0.040**	0.017	0.002	0.017
	(2.21)	(0.04)	(2.21)	(0.90)	(0.04)	(0.90)
Fixedratio	-0.684***	-0.762***	-0.671***	-0.790***	-0.762***	-0.795***
	(-8.72)	(-4.00)	(-8.60)	(-10.39)	(-4.00)	(-10.43)
Constant	-6.700***	-9.800***	-6.525***	-3.514***	-9.800***	-3.585***
	(-28.54)	(-15.88)	(-25.92)	(-15.58)	(-15.88)	(-14.77)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	2583	2583	2583	2583	2583	2583
adj. R^2	0.793	0.239	0.794	0.636	0.239	0.636
F	311.599	26.752	302.418	141.168	26.752	136.602

Note: This table shows the mediating Effect of innovation on the ESG - TFP link. Columns (1)-(3) are the regression results of TFP measured by TFP_LP, and columns (4)-(6) are the regression results of TFP measured by TFP_OP. The t-statistics, reported in parentheses, are based on heteroscedasticity-consistent standard errors clustered by firm and year. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Figures

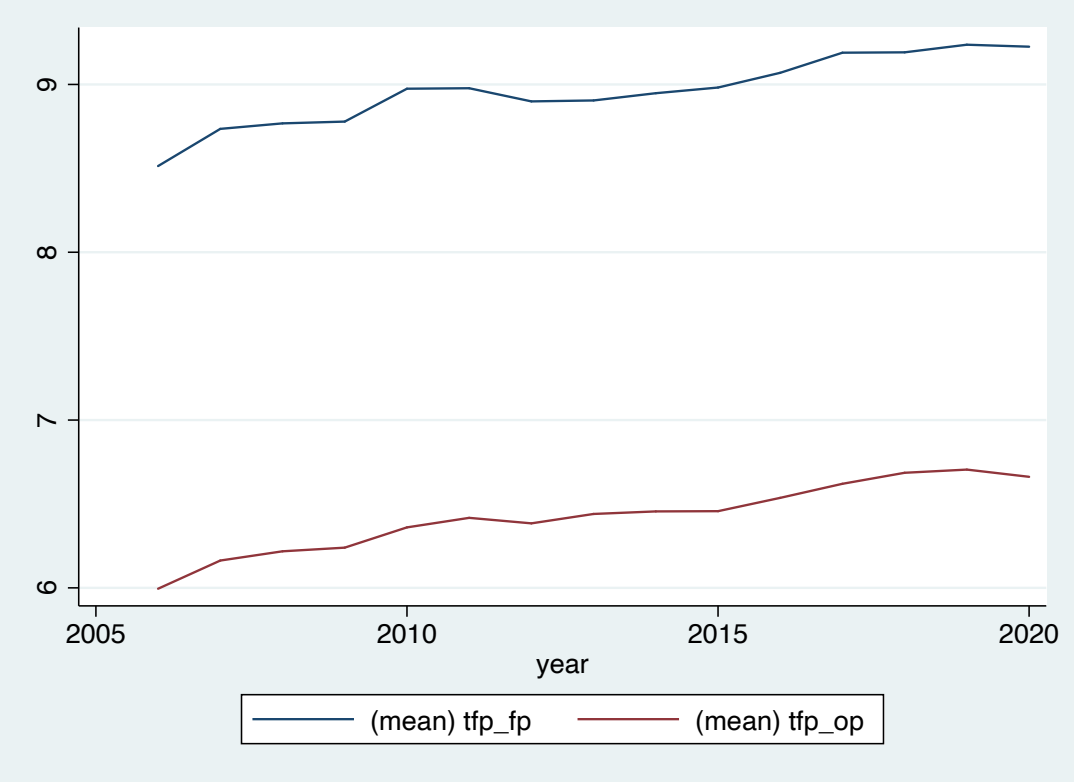

FIGURE 3.1: Trend of the means of TFP over the years

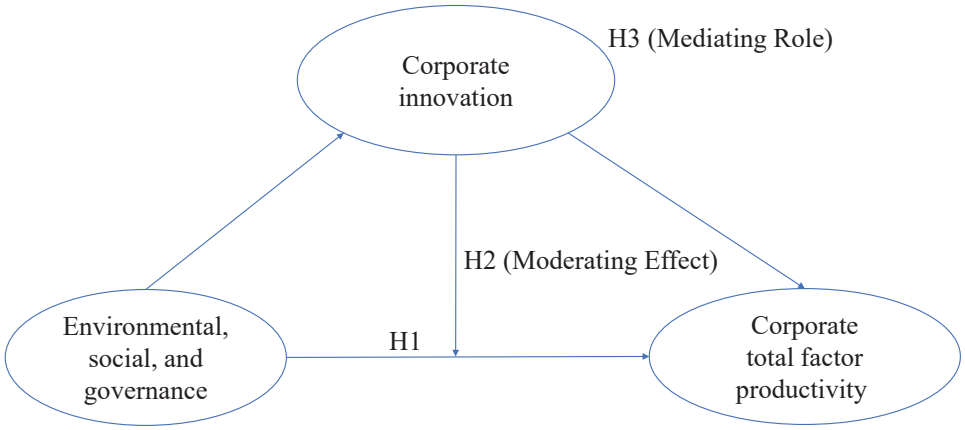

FIGURE 3.2: Conceptual framework

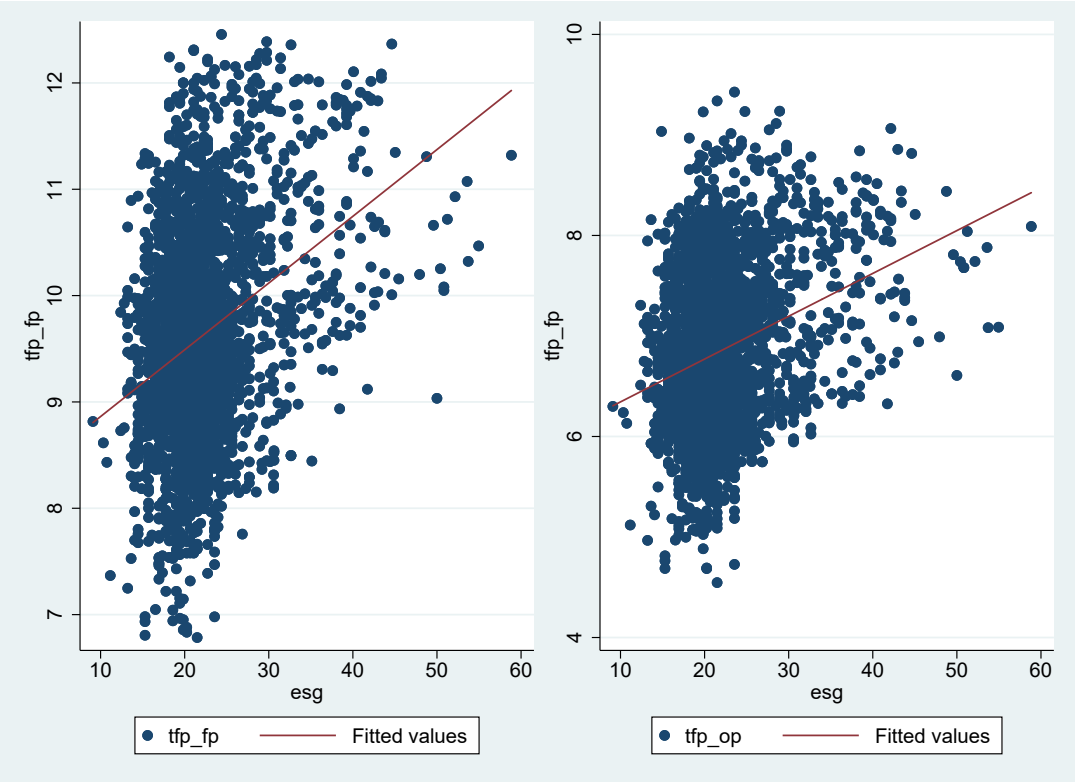

FIGURE 3.3: Relationship between ESG and TFP

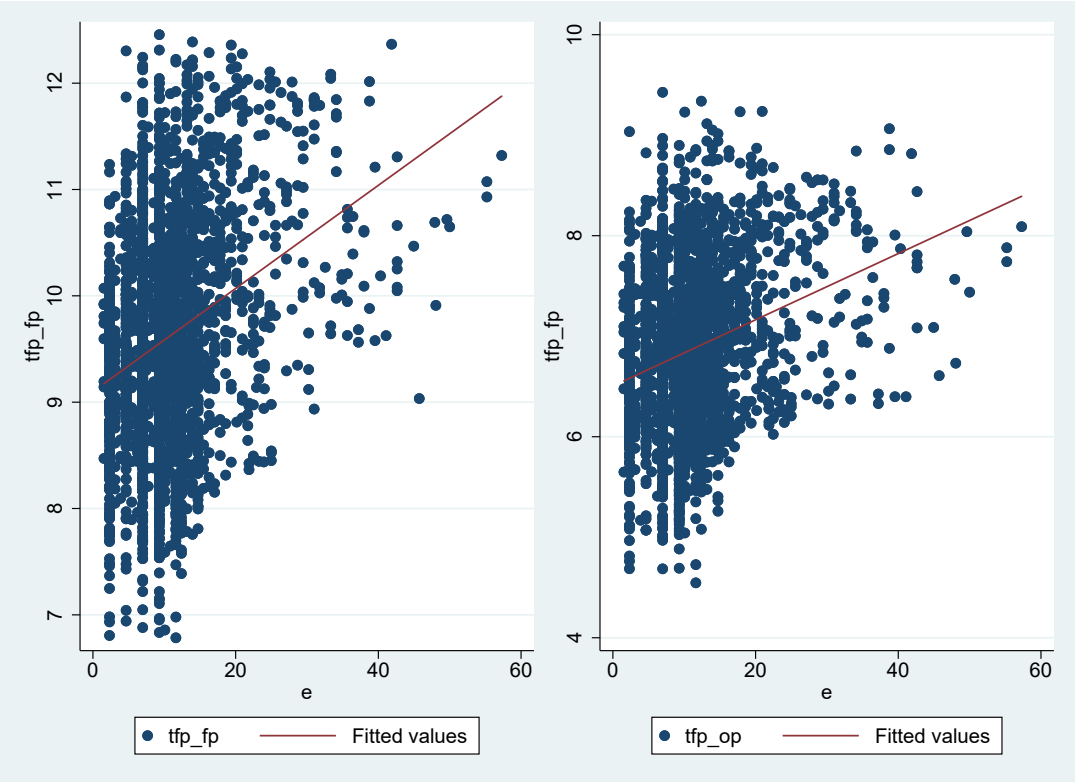

FIGURE 3.4: Relationship between E and TFP

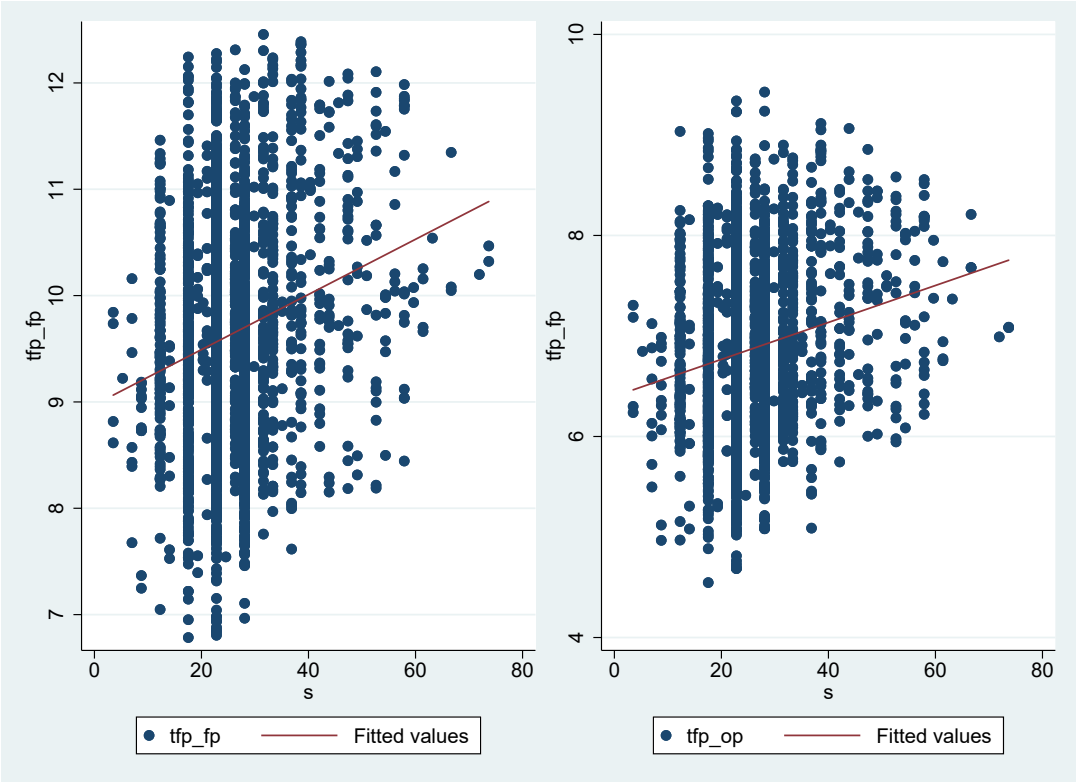

FIGURE 3.5: Relationship between S and TFP

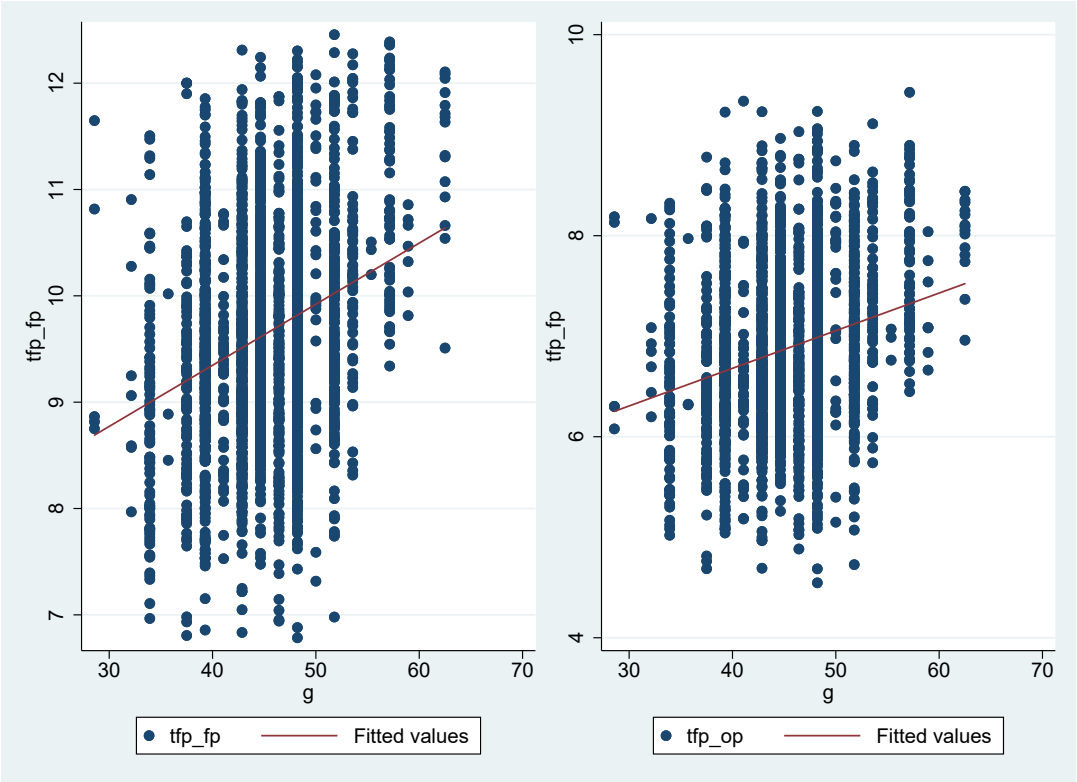

FIGURE 3.6: Relationship between G and TFP

Appendix A: OP method

We use both the Olley-Pakes method (OP method for short) and Levinsohn-Petrin method (LP method for short) to measure TFP in this chapter. The specific explanation of these two methods mainly refers to Lu and Lian (2012). Before estimating total factor productivity, the form of the production function needs to be set. The Cobb-Douglas (C-D) production function is the most commonly used functional form because of its simple structure and intuitive and common sense for the measurement of economies of scale. Here is the C-D production function:

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta} \tag{3.5}$$

Y_{it} represents the output, L_{it} and K_{it} represent the input of labor and capital, respectively. A_{it} is TFP, which can simultaneously increase the marginal output level of various factors. By taking the logarithm of equation (3.5), it can be transformed into the following linear form:

$$y_{it} = \alpha l_{it} + \beta k_{it} + u_{it} \tag{3.6}$$

where y_{it}, l_{it} and k_{it} represent the logarithmic form of Y_{it}, L_{it} and K_{it} respectively. The residual term of equation (3.6) contains the information in the logarithmic form of A_{it}. Equation (3.6) can be estimated to obtain an estimate of TFP.

However, when the above simple linear estimation method is used for enterprise TFP estimation, there will be inevitable measurement technical problems, namely simultaneity bias and sample selection bias.

To solve the simultaneity bias problem, the residual term of equation (3.6) can be split in the following form:

$$y_{it} = \alpha l_{it} + \beta k_{it} + \omega_{it} + e_{it} \tag{3.7}$$

Among them, ϖ^{it} is a part of the residual item, which can be observed by the enterprise and affects the selection of factors in the current period. e_{it} is the true residual term, containing unobservable technical shocks and measurement errors.

The OP method, developed by Olley and Pakes (1996), is based on consistent semi-parameter estimation. The method assumes that enterprises make investment decisions based on the current state of firm productivity, so the current investment of enterprises is used as a proxy variable for unobservable productivity shocks, thus solving the problem of simultaneity bias. The method mainly consists of two steps:

First, establish the relationship between the current capital stock of the enterprise and the investment amount:

$$K_{it+1} = (1 - \delta)K_{it} + I_{it} \tag{3.8}$$

Where K is the capital stock of the firm, and I is the current investment. This formula shows that the current capital value of the firm and the investment are orthogonal. In addition, the process assumes that if there is a high expectation for the future of ϖ, then the company tends to increase the current investment, that is, the higher the current ϖ, the higher the current investment. Based on this, an optimal investment function is constructed as follows:

$$i_{it} = i_t\left(\varpi, k_{it}\right) \tag{3.9}$$

To obtain the inverse of this optimal investment function, assuming $h() = i^{-1}()$, ϖ can be written as:

$$\varpi_{it} = h_t\left(i_{it}, k_{it}\right) \tag{3.10}$$

Then, substituting equation (3.10) into the production function estimation equation, we obtain:

$$y_{it} = \beta \cdot l_{it} + \gamma \cdot k_{it} + h_t\left(i_{it}, k_{it}\right) + e_{it} \tag{3.11}$$

The former term on the right-hand side of the equation (3.11) represents the contribution of labor, and the latter term represents the contribution of capital. Define the latter term as:

$$\phi_{it} = \gamma \cdot k_{it} + h_t\left(i_{it}, k_{it}\right) \tag{3.12}$$

ϕ_{it} can be represented by a polynomial containing the logarithm of the investment amount and the capital stock, defined as an estimate of $\widetilde{\phi}_{it}$. Therefore, the following equation can be estimated by the first step:

$$y_{\dot{s}} = \beta \cdot l_{it} + \phi_t + e_{\dot{t}} \tag{3.13}$$

By estimating equation (3.13), the consistent unbiased estimation coefficient of the labor term can be obtained. Next, the estimated coefficients are used to fit the value of the polynomial $\widetilde{\phi}_{it}$ consisting of the investment amount and the capital stock.

After obtaining the estimated coefficients for the labor term, the second step focuses on estimating the coefficients for the capital term. First define $V_{it} = y_{it} - \hat{\beta} \cdot l_{it}$, then estimate the following equation:

$$V_{it} = \gamma \cdot k_{it} + g\left(\phi_{t-1} - \gamma k_{it-1}\right) + \mu_{it} + e_{it} \tag{3.14}$$

Where $g(\cdot)$ is a function that includes ϕ and the capital stock lag. This function can be estimated by higher order polynomials of ϕ_{t-1} and k_{t-1}.

Olley and Pakes (1996) also considered sample selection bias and proposed a corresponding solution. After obtaining a consistent and unbiased estimate of labor input by constructing a polynomial ϕ_{it} containing the logarithm of investment and capital stock, a survival probability is used to estimate firm entry and exit, thereby controlling for sample selection bias. The optimal decision of an enterprise can be

characterized by the following Bellman equation:

$$\begin{aligned} V_{it}\left(K_{it}, a_{it}, \omega_{it}\right) = \operatorname{Max}\Big\{ & \Phi, \operatorname{Sup}_{I_{it0}} \Pi_{it}\left(K_{it}, a_{it}, \omega_{it}\right) \\ & -C\left(I_{it}\right) + \rho E\left[V_{i,t+1}\left(K_{i,t+1}, a_{i,t+1}, \omega_{i,t+1}\right) \mid J_{it}\right]\Big\} \end{aligned} \tag{3.15}$$

Among them, $\pi_{it}(\cdot)$ represents the profit function of the enterprise, $C(\cdot)$ represents the current investment cost, ρ is the discount factor, and $E\left[\cdot \mid J_{it}\right]$ represents the future expectation factor of the information set J_{it} in period t. The Bellman equation states that a firm will exit the market when its liquidation value Φ exceeds its expected discounted return. Hence the following exit functions exist:

$$\chi_{it} = \begin{cases} 1, & \text{if } \omega_{it} >= \underline{\omega}_{it}\left(K_{it}, a_{it}\right) \\ 0, & \text{otherwise} \end{cases} \tag{3.16}$$

Here, χ represents the survival state, when it is 1, it means continuing to operate, and when it is 0, it means exiting the market. The exit decision of an enterprise depends on a technical threshold $\underline{\omega}$. If the actual productivity is higher than this threshold, the enterprise will continue to operate, otherwise, it will exit the industry. Therefore, we can use the following Probit model to describe the above decision-making mechanism:

$$\begin{aligned} \Pr\left(\chi_{it} = 1 \mid J_{i,t-1}\right) &= \Pr\left(\chi_{i,t} = 1 \mid \omega_{it-1}, \hat{\omega}_{i,t}\left(k_{i,t+1}\right)\right) \\ &= \varphi\left(i_{i,t-1}, k_{i,t-1}\right) \end{aligned} \tag{3.17}$$

In the second step regression, the above Probit fitting value can be substituted into equation (3.14), and we obtain:

$$V_{it} = \gamma \cdot k_{it} + g\left(\phi_{t-1} - \gamma k_{it-1}, \hat{P}_{t-1}\right) + \mu_{it} + e_{it} \tag{3.18}$$

In this extended equation, $g()$ can be represented by a higher-order polynomial including ϕ_{t-1}, k_{t-1} and $\hat{P}_{t-1}$. Thus, even in the presence of sample selection bias,

this treatment yields consistent estimates of capital items.

Once equation (3.14) is estimated, all the coefficients in the production function will be successfully estimated. Using this result, we can fit equation (3.6) to obtain the log value of the residual, which is the log of total factor productivity.

Appendix B: LP method

The OP method can provide consistent estimates of firm-level production functions if the proxy variable (investment) is always monotonic with total output. This means that samples with zero investment cannot be estimated. Because not every firm has a positive investment every year, many firm samples are discarded in the estimation process. Levinsohn and Petrin (2003) developed a new TFP estimation method, LP method, for this problem. The LP method does not use the investment amount as a proxy variable but instead uses the intermediate product input index, which is easier to obtain from the data point of view. It also allows researchers to flexibly select proxy variables according to the characteristics of the available data.

Conclusion

This thesis aims to explore how corporate sustainability affects firm performance in China. We have studied the increased CER effectiveness in periods of strict environmental policy, the non-monotonic relationship between ESG and stock price crash risk, and the positive role of ESG and individual pillars in improving firm productivity.

In the first chapter, we investigate the evolutionary impact of CER on firm value using data from Chinese A-listed firms from 2006 to 2019. We first examine whether there is a significant difference in CER's effectiveness on firm value between a steady period with lax environmental enforcement and a shaky period with strict environmental enforcement. Then, we investigate the moderating role of ownership types on that relationship in the two periods to check local protectionism's role. Our results show that, first, CER negatively affects firm value in the steady period, but positively affects it in the shaky period. Second, we find that enterprises that previously received more local protection show larger increments in CER effectiveness. To the best of my knowledge, most existing research[9] explores the effectiveness of CER in a stable background, resulting in the same consequence for the same CER engagement level; and few existing studies link changes in CER effects to changes in the intensity of local protectionism during China's centralization process. Compared with previous literature, this study has two main contributions. First, it is the first to investigate CER effectiveness under varying institutional circumstances. The results show that the effect of CER on firm value is not homogenous across different institutional backgrounds, and the effect increases significantly when environmental

[9]Such as Li et al. (2020) and Xu et al. (2021).

enforcement is more stringent. Second, since firm ownership type is closely connected with the strength of local protection, we investigated the moderating effect of ownership type to dig deeper into local protectionism's role. Our results demonstrate it is the weakened local protectionism after 2016 that caused the increase in CER's effect. Our findings are very relevant to firm management, investors, and policymakers. When deciding on CER investment, managers should comprehensively consider company's characteristics and institutional background to optimize their results.

In the second chapter, we examine the effect of ESG disclosure on firm-specific stock price crash risk. There are two different views on this issue. Stakeholder theory states that undertaking ESG disclosure helps to increase a firm's transparency, decrease bad news hoarding behavior, and thus reduce the stock price crash risk. On the contrary, agency theory believes that managers may use ESG disclosure as a tool to gain their benefit and conceal bad news, hence raising the crash risk. In addition to literature analysis, we also explore two impact channels and propose an analytical model to prove a non-monotonic relationship between ESG and crash risk. Afterward, we explored the relationship between ESG and crash risk with empirical research. Using the Chinese A-share listed firms during the year 2006-2020 as a sample, we find a non-monotonic relationship between ESG and crash risk, and the relationship holds after controlling other impacting factors and considering potential endogenous problems. This finding means that the discretionary disclosure of ESG information has a complex association with firm-specific stock price crash risk. Specifically, as the firm discloses more ESG information, the crash risk first decreases and increases afterward. Most of the existing studies only explore the relationship between ESG and crash risk from an empirical perspective and find a negative relationship[10]. Different from the existing literature, our two main contributions are: first, we explore the relationship between ESG and crash risk from both theoretical and empirical perspectives; second, we find a non-monotonic relationship between

[10]See Dai et al. (2019) and Feng et al. (2021) as examples.

the two variables. This study amplifies the growing ESG literature, expands the scope of ESG research, and enriches the understanding of ESG's relative economic impact. Our results provide a reference value for Chinese managers, investors, and related government departments to assess the effect of ESG scores and provide relative regulators to prevent abnormal instabilities in the Chinese stock market.

In the third chapter, we explore the impact of ESG (and its individual pillars) on firms' TFP and the moderating and mediating roles of innovation in this relationship. Using a sample of Chinese listed companies from 2005 to 2020, we find that, first, the total ESG score and its pillars have a significant and positive relationship with the firm's TFP; namely, the company's ESG performance can improve firm's production efficiency, thereby improving market competitiveness. The results are consistent after using the instrumental variable method to alleviate the endogeneity concerns. In the robust test, we removed the years with a small amount of data and changed the way the variables were measured, and the results were still consistent. Second, we found that the firm's innovation level partially mediates the ESG-TFP relationship. Namely, the promotion of ESG to TFP is partly achieved by improving the innovation level. The mediating effect of innovation also exists in the relationship between three sub-dimensions and TFP. Finally, we find that firm innovation can moderate the relationship between ESG and TFP. Specifically, in companies with relatively low innovation, the promotion effect of ESG on TFP is more obvious. Previous research, such as Deng and Cheng (2019), mainly focuses on the effect of ESG on financial performance, which is measured by financial metrics such as ROA, Tobin's Q, cost of capital, etc. Compared with those studies, our contribution is that we explore the relationship between ESG and firm productivity and attach importance to firm innovation. In theory, our research amplifies the expanding ESG-related literature, enriches the understanding of the economic consequences of corporate ESG performance, and also complements the literature on factors influencing firms' TFP.

Our results improve the understanding of the relationship between corporate responsible investment and corporate efficiency. In reality, our findings provide a reference for Chinese corporate administrators, investors, and related governors to assess the effectiveness of corporate ESG investment and innovation, and also provide a way for corporate managers to improve corporate efficiency.

Previous literature[11] on the relationship between ESG (or sub-dimensions such as CSR and CER) and firm performance came to different results, positive, negative, non-linear, or neutral. The reasons for the different results may be that data used are from different time periods, the data sample used are from different industries, and the firms are in regions with different regulatory levels (some have matured and strict regulatory systems, while others have immature and loose regulatory systems), etc. We add to them by finding that different environmental policies, different levels of ESG disclosures, and different levels of innovation will affect the effectiveness of ESG (or sub-dimensions).

We have obtained the following unique findings specific to China. First, before China strengthened environmental control, CER had no significant positive value to the company. After the environmental policy was strict, the value of CER to the company increased significantly. However, the background of many national mechanisms remains unchanged, so the value of CER to the company is generally positive or negative. Second, regarding the link between ESG and stock price crash risk, many other countries generally have a negative relationship. Using data from Chinese listed companies, we find a non-monotonic relationship. This may be because China's market supervision system is immature compared to the mature market supervision in developed countries, and companies are more likely to hide negative news within the company by falsifying good ESG performance, thereby increasing the risk of stock crashes. Therefore, in China, high ESG may reflect high risk. Third, the positive effect of ESG on TFP is more obvious in Chinese enterprises than enterprises in developed countries, because Chinese enterprises generally have

[11] See Margolis and Walsh (2003), Deng et al. (2013) and Xie et al. (2019) as examples.

weaker innovation ability compared with those companies in developed countries (Crescenzi and Rodríguez-Pose, 2012), and thus investing resources into ESG activities can improve company productivity more efficiently. For example, by participating in ESG-related activities, companies can learn new technologies, management skills, and demonstrate a good reputation, thereby reducing asset and product costs.

Our findings are very relevant to corporate managers, investors, and related government departments. The results suggest that when firm's managers make decisions related to ESG disclosure or engagement, they need to consider multiple factors, namely the institutional background, their own characteristics, and the degree of ESG disclosure, in order to enhance company value, stabilize stock prices, and improve production efficiency. For investors, the effective use of ESG information can help better judge firms' policy-related risk resilience, stock price stability, and productivity potential. For policymakers, it would be beneficial to formulate policies to scientifically guide companies in ESG disclosure and engagement, so as to improve environmental sustainability, maintain capital market stability, and increase productivity.

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