Essays on political influence and sustainability in Banking and Financial Markets

Wenjing Zhang

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Abstract

This thesis investigates the effects of environmental events and public governance within the Chinese context, focusing on three key research questions: (1) Do local firms strategically enhance Corporate Social Responsibility (CSR) following regional pollution emergencies? (2) How does the 'policy mix' of green credit policies and government subsidies influence high-quality environmental innovation in high-polluting firms? (3) What is the impact of political corruption on stock liquidity?

Utilizing a large sample of Chinese listed firms, this thesis employs robust empirical methods, including instrumental variables, propensity score matching (PSM), and difference-in-difference tests, to ensure the validity of its findings. The research reveals that firm-level outcomes are significantly influenced by regional pollution emergencies, environmental policy mixes, and political corruption.

Chapter 1 addresses the rising incidence of pollution emergencies in China and examines how local firms use CSR initiatives to build trust and counteract negative stakeholder sentiments following severe pollution events. It identifies political dependency, institutional ownership, and public monitoring as primary drivers of enhanced CSR activities, contributing to the literature on corporate responses to environmental shocks

Chapter 2 explores the impact of the Green Credit Guidelines (GCGs) in China and the moderating role of government subsidies. The findings indicate that GCGs negatively affect high-quality environmental innovation among high-polluting firms, but government subsidies can mitigate this negative impact. This work adds to the literature on the implications of environmental policy mixes.

Chapter 3 investigates the relationship between political corruption and stock liquidity, revealing that local political corruption negatively impacts stock liquidity through informational channels and investor trading activities. This chapter contributes to the extensive research on the effects of corruption.

By focusing on environmental innovation, CSR, and stock liquidity, this thesis highlights significant contributions to the broader literature on political influence and sustainability in banking and financial Markets.

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I dedicate this thesis to my parents, my grandparents, my uncle, and my other family members. Their love and support have accompanied me and inspired me throughout my studies.

Statement on Joint Authorship for Thesis Submission

I, Wenjing Zhang, a postgraduate researcher at the University of Nottingham, hereby declare that paper titled “Building trust after pollution emergency: A strategic perspective on corporate social responsibility” submitted as part of my thesis is the original draft of published paper:

Ma, Y., Ding, Y., Wang, Z., & Zhang, W. (2023). Building trust after pollution emergency: A strategic perspective on corporate social responsibility. Energy Economics, 126, 106989.

The published paper was co-authored with Dr Zilong Wang, Professor Yechi Ma and Professor Yibing Ding. My contribution to this chapter encompassed Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing. I assert that my contribution as the main author was substantial and that I have met the authorship requirements as defined by the guidelines of the Finance field of study.

I have obtained a written statement from Dr Zilong Wang, Professor Yechi Ma and Professor Yibing Ding in which they concur with the description of the extent of my contribution to the joint paper(s), and I have included this statement with my thesis submission.

I affirm my commitment to academic integrity and ethical conduct and attest that the information provided in this statement is true and accurate to the best of my knowledge. I understand that providing false information in this statement may result in disciplinary action by the University.

Statement on Joint Authorship for Thesis Submission

I, Wenjing Zhang, a postgraduate researcher at the University of Nottingham, hereby declare that the paper titled "Adding Carrot to Stick: Green Credit, Government Subsidy and High-quality Environmental Innovation" submitted as part of my thesis is the original draft of published paper:

Ma, Y., Sha, Y., Wang, Z., & Zhang, W. (2023). The effect of the policy mix of green credit and government subsidy on environmental innovation. Energy Economics, 118, 106512.

The published paper was co-authored with Dr Zilong Wang, Dr Yezhou Sha, and Professor Yechi Ma, and that my contribution to this chapter encompassed Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing. I assert that my contribution as the main author was substantial and that I have met the authorship requirements as defined by the guidelines of the Finance field of study.

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Written Statement from Co-Author Confirming Contribution to Joint Paper(s)

I, Dr Zilong Wang, co-author of the papers titled “Building trust after pollution emergency: A strategic perspective on corporate social responsibility” and “The effect of the policy mix of green credit and government subsidy on environmental innovation” submitted by Wenjing Zhang as part of her PhD thesis, hereby confirm that I agree with the description of the extent of Wenjing Zhang's contribution to the joint paper(s). Specifically, I confirm that Wenjing Zhang made a substantial contribution to the Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing of the papers as the main author.

I understand that this statement will be included with Wenjing Zhang's thesis submission, and that it will be used by the Assessors to evaluate Wenjing Zhang's contribution to the joint paper(s).

I affirm my commitment to academic integrity and ethical conduct, and attest that the information provided in this statement is true and accurate to the best of my knowledge.

Zilong Wang

Zilong Wang

Senior Research Associate

University of Cambridge, UK

Written Statement from Co-Author Confirming Contribution to Joint Paper(s)

I, Professor Yechi Ma, co-author of the papers titled “Building trust after pollution emergency: A strategic perspective on corporate social responsibility” and “The effect of the policy mix of green credit and government subsidy on environmental innovation” submitted by Wenjing Zhang as part of her PhD thesis, hereby confirm that I agree with the description of the extent of Wenjing Zhang's contribution to the joint paper(s). Specifically, I confirm that Wenjing Zhang made a substantial contribution to the Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing of the papers as the main author.

I understand that this statement will be included with Wenjing Zhang's thesis submission, and that it will be used by the Assessors to evaluate Wenjing Zhang's contribution to the joint paper(s).

I affirm my commitment to academic integrity and ethical conduct, and attest that the information provided in this statement is true and accurate to the best of my knowledge.

Professor Yechi Ma

Northeast Normal University

Changchun, Jilin, China

Written Statement from Co-Author Confirming Contribution to Joint Paper(s)

I, Dr Yezhou Sha, co-author of the paper titled "The effect of the policy mix of green credit and government subsidy on environmental innovation" submitted by Wenjing Zhang as part of her PhD thesis, hereby confirm that I agree with the description of the extent of Wenjing Zhang's contribution to the joint paper. Specifically, I confirm that Wenjing Zhang made a substantial contribution to the Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing of the papers as the main author.

I understand that this statement will be included with Wenjing Zhang's thesis submission, and that it will be used by the Assessors to evaluate Wenjing Zhang's contribution to the joint paper.

I affirm my commitment to academic integrity and ethical conduct, and attest that the information provided in this statement is true and accurate to the best of my knowledge.

Yezhou Sha

Yezhou Sha, PhD

Associate Professor

Capital University of Economics and Business

Beijing, China, 100070

Written Statement from Co-Author Confirming Contribution to Joint Paper(s)

I, Professor Yibing Ding, co-author of the paper titled “Building trust after pollution emergency: A strategic perspective on corporate social responsibility” submitted by Wenjing Zhang as part of her PhD thesis, hereby confirm that I agree with the description of the extent of Wenjing Zhang's contribution to the joint paper. Specifically, I confirm that Wenjing Zhang made a substantial contribution to the Conceptualization, Software, Data curation, Methodology, Investigation, Formal analysis, and Writing of the papers as the main author.

I understand that this statement will be included with Wenjing Zhang's thesis submission, and that it will be used by the Assessors to evaluate Wenjing Zhang's contribution to the joint paper.

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List of Contents

List of Tables

List of Figures

List of Abbreviations

SOE	State owned Enterprise
CSR	Corporate Social Responsibility
SRI	Socially Responsible Investment
DID	Difference in Difference
DDD	Difference in Difference in Difference
GDP	Gross Domestic Product
GCG	Green Credit Guideline
PSM	Propensity Score Matching
CPC	Communist Party of China
CCCPC	Central Committee of the Communist Party of China
GLF	Great Leap Forward
R&D	Research and development
IV	Instrument Variable
CSMAR	China Stock Market and Accounting Research Database
CSS	Chinese Social Survey

Introduction

Firms constantly interact with various stakeholders, among which, the government is considered as one of the most important. Particularly for emerging markets, government intervention in business activities through, for example, taxation, regulation, and direct ownership is common. Governments influence and control every aspect of a firm: from input such as financing, labor, land, energy, infrastructure, etc., to the production process and outputs. Given the extensive government intervention in firms, the political pressure when extreme events occur, the formulation and implementation of public policies, and ultimately the quality of government are critical impacting factors for firms in emerging market. Prior law and finance literature identifies government as a key institutional factor and shows that a high-quality government contributes to macroeconomic growth (Beck and Laeven, 2006), and government policy changes are associated with stock market volatilities and correlations (Pástor and Veronesi, 2012). At the micro level, there is also a rich body of research on the role of government in shaping firms' behavior and performance. This thesis adds to these studies and explores whether firm level outcomes influenced by: i) Regional environmental emergencies induced negative judgement of stakeholder such as government; ii) government's environmental policy mix of green credit policy and subsidy; and iii) political corruption.

As the world's second largest economy, China has experienced spectacular economic growth since the advent of the "reform and opening policy" in 1978. However, economic growth in China is accompanied by high levels of environmental pollution. Government play an important role in environmental protection, committed to guiding firms to be greener. While governments generally play a role in environmental issues in many countries, the situation in China is particularly interesting. In China's transition from a planned economy to a market economy, a mixture of legal, administrative and market mechanisms have emerged, but the government's traditional "iron fist" has not been completely abandoned. Moreover, in recent years, Chinese government attached much importance to environmental protection and enacted a series of innovative environmental policies including various regulatory and incentive measures. The fact that firms in China operate under political pressure and public environmental policies makes it a natural laboratory for researchers to directly investigate the role of government in pollution issues.

In addition to environmental pollution, widespread corruption is another problem that accompanies economic development in China. Government officials make mistakes; they may have self-interests or be even corrupt. The government's degree of probity determines the institutional setting that firms face, which has extensive implications on firm behavior and performance. Overall, in China, firm decision and performance are closely related to political pressure, public policies, and public governance. This thesis focuses on the frequent occurrence of pollution incidents and the wide existence of political corruption in China.

Firstly, extensive economic growth can breed severe pollution. According to 2022 Environmental Performance Index, China ranked 160th out of 180 countries in the world, which indicates that China's air and water quality, biodiversity, and climate change is not optimistic. Increasing environmental pollution is harmful to human health and other socioeconomic indicators. Industrial firms are primary consumers of energy resources and major emitters of pollutants. In extreme cases, corporate environmental misconducts trigger regional pollution emergencies, which place the public at risk and lead to extensive condemnation. The negative judgement of stakeholder such as government would in turn influence firm behaviors.

Secondly, as a representative of the public interest, the government are committed to guiding firms to engage in environmental protection, greener production, and pollution abatement through environmental regulation and incentive measure. A series attempts are being made by Chinese government to remedy the pollution hazard and to protect the environment. Green credit policy and government subsidy are among these attempts. Green credit policy is a special form of environmental regulation and requires commercial banks to fully assess environmental risks when granting credit. Moreover, the Chinese government offers extensive subsidies to support the green translation of firms. These public policies would influence firms' environmental behavior.

Thirdly, corruption has become one of China's core social and political problems. Due to the heavy government intervention on business activities and lack of a legal system, independent news media, and legal political opposition to restrain administrative power, China faces severe corruption. In addition, In China, the culture of "guanxi" has been prevalent since ancient times, which refers to the use of interpersonal resources in exchange for benefits, which induce corruption. According to Corruption Perception Index released by Transparency International, China's score is only about 40, out of a total score of 100. Political corruption may be adversely related to firm-specific outcomes by shaping business environments.

Our research is motivated by a stream of previous studies focusing on the effect of political engagement, public policies, and institutional setting (e.g., Lin et al. (2015); Gollop and Roberts (1983); Huang and Yuan (2021)). The main motivation for this research work is built on three types of limitations of existing literature. First, prior research draws inferences on political pressure in a static setting, mainly from the perspective of political connection, state ownership government hierarchy and political competition (Pan and Tian, 2020; Dong et al., 2021; Cheung, et al., 2010; Besley et al., 2010). Hence it overlooks the exogenous variation of political pressure. Particularly in the case of emergencies with serious social implication, the impact of increased political pressure on firm behavior remains to explore. Secondly, on the role of public environmental policies on firm innovation, the conclusion is mixed. Theoretically, environmental regulation internalizes the external costs of highly polluting firms, changing the equilibrium between firms and the public interest, encouraging firms to carry on environmental-friendly transformation (Porter and Linde, 1995). On the contrary, according to neoclassical economic theory, environmental regulation increases compliance costs, squeezes out funds used for R&D, and limits firms' ability to innovate, which is a phenomenon known as the 'compliance cost' effect (Gollop and Roberts, 1983; Wagner, 2007). Previous literature also has found that government subsidies have two opposite effects on firm innovation. On the one hand, researchers who support the incentive effect claim that government subsidies promote independent innovation of firms (Gao et al., 2021). On the other hand, researchers who proposed the crowding-out effect believe that government subsidies are not necessarily positively related to innovation and some firms strive for more government subsidies by expanding production scale rather than innovating. (Wadho and Chaudhry, 2018). In the Chinese context, facing serious pollution problems, the impact of different policies on corporate environmental innovation is yet to be explored. In addition, the lack of empirical studies on policy mix constitutes a remarkable gap because Chinese government implement various policy instruments to promote firms' innovation especially environmental innovation. Thirdly, because survey data are available, extensive research on corruption focuses on international settings (Wu, 2006; Barkemeyer et al., 2018; Ferris et al., 2021). However, research based on a single country has advantage in controlling for institutional (e.g., investor protection) and cultural (e.g., interpersonal relationships) differences at the national level (Fisman and Gatti, 2002). Further, compared with developed countries, typically with low corruption level, China characterized by unique political and firm relationships which breed corruption provides an ideal setting to study the effect of corruption.

In this context, this thesis is structured as follows. The first chapter uses extreme regional pollution emergencies as exogenous shocks to the trust of stakeholders such as government to test local firms' response in terms of CSR. This chapter asks whether local firms especially highly-polluting firms strategically improve CSR to build trust following pollution emergencies and whether their CSR strategy is rewarded. This builds on prior research by drawing attention to CSR as a specific strategy through which firms may use after extreme negative events under pressure from stakeholders represented by governments.

The second chapter focuses on the effectiveness of the public environmental policy mix. Especially, green credit policy is used to regulate firms' emission behavior, and subsidies are used to support environment transformation. This chapter examines whether and how 'policy mix' of green credit policy and government subsidy affects high-quality environmental innovation of high-polluting firms in China. Contrary to prior research, this work presents the interaction effect of joint policies (comprising both green credit policy and subsidies) on the development of environmental innovation, especially for highly polluting firms.

Finally, the third chapter explores implications of political corruption on firms' stock market performance. Political corruption can affect firm's secondary-market liquidity through two primary mechanisms: altering the stock trading activity and changing firms' information environment. This chapter examines whether political corruption impedes stock liquidity exploiting the variations in the corruption environments among provinces in China. This builds on prior research by drawing attention to political corruption as a specific factor determine the stock liquidity in emerging market firms.

Putting these arguments together, this thesis aspires to promote a better understanding of the role of political pressure in terms of environmental protection, public environmental policy mix, and political corruption on firm-level outcomes. China is the world's largest emerging market and a key component of the global economy. In view of China's influence on the environmental protection and global economy, understanding its environmental practices and the role of Chinese government in business activities has implications for global regulators, ecosystem conservation groups, investors, and corporate managers.

~ CHAPTER ONE ~
Building trust after pollution emergency: A strategic perspective on corporate social responsibility

Abstract

We use extreme regional pollution emergencies to provide new evidence regarding the motivations for corporate social responsibility (CSR). We document that local firms strategically improve CSR to build trust following pollution emergencies, and this is specifically true for highly-polluting firms. Firms face different intensities of external pressures from their stakeholders. In particular, following pollution emergencies, political dependency, institutional investor and public monitoring are the main sources of stakeholder pressure and drivers of the improved CSR. We further find that firms that gain trust through CSR activities after pollution emergencies are rewarded. CSR serves as a buffer against financial constraints, financing distress and negative profitability effect following emergencies. This study contributes to the CSR literature on trust-building motivated CSR strategies.

1.1 Introduction

The issue of corporate social responsibility (henceforth "CSR") has become increasingly important over recent years. Growing numbers of firms have regularly engaged in CSR activities and routinely include CSR activities in their corporate strategies (McWilliams and Siegel, 2001), which is a response to society's call for responsible firms. In addition, research also has indicated that firms use CSR as a means of trust building or maintenance, which can be regarded as a kind of strategic investment (Fombrun and Shanley, 1990; Jones, 1995; McWilliams et al, 2006). Previous studies have shown that CSR activities are positively related to firm value for firms with high customer awareness (Servaes and Tamayo, 2013), offer insurance-like protection during adverse events (Klein and Dawar, 2004; Schnietz and Epstein, 2005; Koehn and Ueng, 2010). Given the value of CSR, the question is, what factors influence the decision on CSR? In this study, we investigate whether firms fulfil their social responsibility to strategically build trust in response to unexpected shock of regional pollution emergencies.

CSR activities are voluntary corporate actions designed to further social good and such activities beyond the explicit economic benefit of the firm (Mackey et al., 2007; McWilliams and Siegel, 2001). Since CSR activities are not required by law, they can be viewed, broadly, as gifts or grants to various stakeholder groups. That does not mean, however, there are no strings attached. CSR is used for trust building (Godfrey et al., 2009) and signaling the willingness of a firm to act altruistically (not purely self-considering). Especially when facing negative social events, CSR can be used as a defensive countermeasure that can generate positive moral capital and build trust among stakeholders, further alleviating damaged trust and corporate reputations (Godfrey, 2005). Stable community connections built via CSR mitigate public concerns, preventing harm to future operations and profitability (Peloza 2006; Sharfman and Fernando 2008). Corporate executives generally believe in the role of CSR in building trust. For example, according to the Annual Global CEO Survey conducted by PricewaterhouseCoopers , CEOs plan to engage in more CSR activities to restore stakeholder trust after the Covid-induced crisis.

China, the "world’s factory”, has undergone spectacular economic growth and modernization, but environmental concerns are rising and corporate environmental misconducts are largely responsible for environmental deterioration (Du et al. 2015). In extreme cases, corporate environmental violations trigger regional pollution emergencies, which place the public at risk and lead to extensive condemnation. In particular, regional pollution emergencies caused by deliberate discharges lead to significant adverse changes in public sentiment. Public environmental concerns thrust local firms into spotlight and make them under tremendous pressure afterwards. In this situation, local firms may suffer from unwarranted influences and desperately need to establish an image of responsible members of society, making stakeholders ignore negative information (Bhattacharya and Sen 2004). Existing studies have proved that CSR is a useful crisis management tactic that helps firms build a reservoir of goodwill and divert the public's attention away from negative environmental shocks (Aguinis and Glavas, 2012). We argue that local firms would use CSR to obtain trust following the occurrence of regional pollution emergencies.

Empirically, verifying whether firms use CSR activities strategically to build stakeholders' trust is not easy. Trust, a kind of subjective perception, cannot be easily measured. To overcome the problem, we utilize regional pollution emergencies caused by environmental violations as exogenous shocks to stakeholders' trust towards local firms, and adopt difference-in-difference (DID) method to investigate firms' CSR strategies after those pollution emergencies. We use this approach basically for two reasons: First, extreme pollution emergencies would attract public attention and cause cognitive reactions from stakeholders. Trust of stakeholders would be extensively undermined following intentional violations (Ouyang et al., 2020; Yu, 2008). Second, a pollution emergency is triggered by a specific environmental violation, and such violation is exogenous to other local firms; that is, their current characteristics cannot influence the disaster. If CSR is used as a means of gaining trust, we should observe that CSR activities of local firms increased subsequent to regional pollution emergencies. However, increases in CSR will not be uniform across firms due to the variant stakeholder pressure (Campbell 2007). We also examine the effectiveness and consequences of using CSR to build trust after pollution emergencies. We argue that firms build trust via CSR and mitigate the negative effects of pollution emergencies. Therefore, we examine whether firms increasing CSR following pollution emergencies outperform their peers that do not improve CSR in terms of profitability, financing constraints and financial distress.

The main results suggest that firms more actively engage in CSR in regions where the trust is undermined because of pollution emergencies and requires rebuilding. We document that the positive impact is more pronounced for highly-polluted firms and the improvement is reflected in all the five sub-indicators of CSR (Shareholder equity responsibility; employee responsibility; supplier, customer, and consumer rights responsibility; environmental responsibility; and social responsibility contribution). We then conduct more analyses to understand the specific mechanisms behind the differences in firm reactions. We find that political dependency, institutional shareholders, and public monitoring are drivers of improved CSR. We further find that firms that gain trust through CSR activities after pollution emergencies are rewarded. These firms do, in fact, experience weaker adverse shocks in terms of profitability, financing constraints and financial distress

This paper makes several contributions. First, this paper adds to the literature about the trust-building value of CSR. The general explanation of how CSR might work is that it can build trust among various stakeholders, which can help temper stakeholders' negative judgments and punishments when adverse events occur (Godfrey, 2005). However, prior research on CSR from the risk management perspective has focused on the relationship between prior-event CSR and post-event firm value. Studies find that a firm's prior-event CSR is associated with smaller decreases in firm value because of adverse events, which could be caused by both internal and external factors (Bansal and Clelland, 2004; Godfrey et al., 2009; Koh et al., 2014). Investigating the role of prior-event CSR is only half of the picture. It remains unclear whether firms proactively use CSR to defuse the trust crisis caused by adverse events. Taking advantage of the unexpected shocks of pollution emergencies, this is the first study to examine firms' post-event CSR strategies. In particular, we examine whether firms engage in more CSR activities after pollution emergencies and what are the resulting benefits.

Second, this paper sheds new light on the general studies on the influencing factors of CSR. Existing papers discuss how firm managers' characteristics and private benefits (Masulis and Reza, 2015; Cronqvist and Yu, 2017), institutional investors (Dyck et al., 2019) affect firms' CSR activities. We show that adverse event plays a significant role in terms of CSR strategies and firms actively engage in CSR activities following regional adverse events.

Finally, we contribute to the studies on how firms respond to environmental emergencies. Existing research takes advantage of a quasi-natural experiment provided by the 2010 BP Deepwater Horizon oil spill and finds that firms respond to the negative environmental sentiment after an environmental disaster by increasing environmental disclosures and improving environmental performance (Heflin and Wallace, 2017; Dyck et al., 2019). However, environmental performance is just one of the CSR components. Barberis and Huang (2001) suggest that people's impressions of a firm are often assessed in one mental accounting, which is the sum of various sub-indicators of CSR. This means that “firms can adopt unrelated spheres to maintain their reputations by offsetting some bad perceptions with some good actions” (Brammer et al., 2009). For example, studies show after environmental misconduct is revealed, firms use charitable donations as a countermeasure to mitigate the negative impact (Du, 2015; Wu et al., 2021). We find in the context of China, firms put effort into every dimension of CSR following regional pollution emergencies, including greater accountability to shareholders, employees, the supply chain, the environment, and society at large to gain trust from stakeholders. We have also demonstrated that political pressure, institutional shareholders, and public exposure are drivers of CSR improvement.

The remainder of the paper is organized as follows: Section 1.2 discusses background related to the regional pollution emergencies and develops hypotheses. Section 1.3 presents the empirical methods and the data. Section 1.4 reports results. Section 1.5 shows the parallel test and robust check and Section 1.6 concludes.

1.2 Background and hypotheses

1.2.1 Background

For a long time, China did not pay much attention to environmental issues because economic growth has always been regarded as the top priority. However, China’s environmental deterioration is increasingly alarming, which has led to a significant increase in public environmental concern. Pollution emergencies remind the Chinese of the importance of protecting the environment. An environmental pollution emergency is an event in which pollutants enter the atmosphere, water, or soil, suddenly causing a decline in environmental quality, and endangering public health, leading to ecological damage and significant social impact. According to the National emergency response plan for environmental emergencies issued in 2014, significant or particularly significant regional pollution emergencies are responded to by provincial governments and reported immediately to the State Council. Any environmental pollution emergency that meets one of the following circumstances is deemed to be significant or particularly significant:

(1) where environmental pollution directly causes more than 10 deaths or more than 50 serious injuries

(2) where more than 10,000 people are evacuated or relocated due to environmental pollution

(3) where direct economic losses of more than 20 million yuan due to environmental pollution

(4) where environmental pollution causes partial loss of regional ecological functions or the death of a large number of wild animals and plants of national priority protection in the region

(5) where interruption of water intake at drinking water sources in county-level cities due to environmental pollution

(6) loss of Class I and II radioactive sources; loss of control of radioisotopes and radioactive devices resulting in more than 3 deaths or more than 10 disabilities; leakage of radioactive substances, resulting in widespread radiation pollution consequences

(7) where sudden environmental pollution emergencies that cause cross-provincial administrative regions or transnational impact.

Extreme pollution emergencies bring continued and significant impacts on society and would raise widespread public concern in the area where the emergency takes place. For example, On 15 January 2012, the water quality of the Longjiang River in Guangxi was abnormal, with cadmium levels exceeding the Class III standard set out in the Environmental Quality Standard for Surface Water by approximately 80 times. The two illegal discharge firms were Jinhe Mining Company Limited and Jinchengjiang Hongquan

Lide Powder Factory, who discharged untreated sewage directly into underground caverns. Experts estimated that the amount of cadmium leaked in this incident was about 20 tonnes. As a result of the contamination of water sources, people in the downstream panicked and purchased water, with bottled water being snapped up in supermarkets. In addition, many fishermen suffered heavy losses, with 1.33 million fish fries dying and 40,000 kilograms of adult fish dying. Production and operation activities of firms are the main sources of pollution. While the immediate negative effect of the cadmium contamination was on the two firms with illegal cadmium emissions, the event arguably focused stakeholders' attention on all local firms. The cadmium contamination accident caused a great deal of public outrage in the region and local firms were also thrust into the limelight. According to an expert involved in the accident, " The firms that caused this emergency are far more than the two announced by the government. ". Shengkun Guo, Party Secretary of the Guangxi Zhuang Autonomous Region, responded to social concerns, stating that a strong determination would be taken to resolutely close some local firms that are not environmentally friendly.

In sum, extreme regional pollution emergencies, especially those caused by intentional discharge, shape the perceptions of stakeholders, including losing their trust. Local firms need to respond strategically to negative stakeholder sentiment.

1.2.2 Hypotheses

As a result of extreme regional pollution emergencies, stakeholders (investors, creditors, regulators, customers, etc.) become more concerned about the likelihood of pollution issues of local firms (more likely) and the severity of their consequences (more severe) (Heflin and Wallace, 2017). When local firms are perceived as possible subjects of similar occurrences, stakeholders would feel alarmed regarding corporate production and worried about the damages associated with it, resulting in losing trust (Midden and Huijts, 2009). Stakeholders punish local firms with sanctions ranging from moderate (badmouthing) to severe (boycotts) as negative sentiment arises. With the increasing public awareness of environmental problems, regional pollution emergencies would lead to more negative stakeholder sentiment and local firms may face more severe penalties.

CSR activities signal that the firm possesses an ‘other-considering’ disposition toward society and further help the firm gain stakeholders’ trust. Prior researches point out that CSR performance enhances a firm’s reputation, thereby leading stakeholders to trust the firm and temper their negative judgments and sanctions (e.g., Pevzner et al., 2015; Lins et al., 2017). Thus, our prediction is that local firms respond to the emergency-induced negative sentiment by increasing their CSR.

An important question is what kind of firms are more likely to spend money on CSR to build trust. Some firms may subject to "common sanctions" and be affected by a particular misfortune because of its certain characteristics (Berchicci and King, 2007). For instance, Barnett and king (2006) find that after Bhopal, firms which are like those where accidents had happened promptly lost value. The above explanation suggests that perceived corporate pollution attributes may further exacerbate stakeholders’ concerns when extreme regional pollution emergencies threaten stakeholders' emotional connections with local firms, engendering low levels of trust. Facing stakeholders’ more unfavorable judge and higher levels of suspicion, firms with higher levels of pollution need to put more effort into CSR to gain trust.

Based on the above analysis, we propose the following two hypotheses:

Hypotheses 1a: Local firms improve CSR subsequent o extreme regional pollution emergencies.

Hypotheses 1b: The improvement of CSR following extreme regional pollution emergencies is more pronounced for the subsample of highly-polluting local firms.

Different stakeholders attach different importance to environmental pollution. Therefore, following the pollution emergency, not all the firms are under the same degree of pressure from stakeholders; those who are under greater stakeholders’ pressure will spend more resources on improving CSR. We identify three sources of pressure, namely, political dependency, institutional shareholder, and public monitoring.

The government's goals involve economic development, social development, and welfare provisions. Governments are important stakeholders at the time of an environmental incident and have a responsibility to address public concerns. However, the government cannot achieve it as a lone player, but needs the buy-in of firms (Lins et al. 2017). The more dependent the firms are on the preferential treatment of the government, the more political pressure these firms are under. Therefore, after the pollution emergency, firms with more political dependency have a greater incentive to gain government trust by improving CSR.

Institutional investors basically make investment decisions based on economic incentives and risk management. To minimize their exposures to negative idiosyncratic event risks, institutional investors may simply tilt their portfolios away from firms with potential environmental risk (Nofsinger et al., 2019). Thus, following pollution emergencies, to prevent the departure of institutional investors with negative sentiments, firms with a higher proportion of institutional investors have a greater incentive to improve CSR to gain trust.

When high environmental risk is perceived, public attention and the resulting public scrutiny can negatively impact the firms' brand image (Hoffman and Ocasio, 2001). Hence local firms have the incentive to gain the public's trust. CSR can be used to manage public impressions and ease the pressure from the public after pollution emergencies. Different firms face different levels of public monitoring. The CSR strategy following pollution emergencies depends on the likelihood of a firm being monitored by the public and the importance the public places on environmental conditions. We propose our hypothesis as follows:

Hypotheses 2: The improvement of CSR following extreme regional pollution emergencies is more pronounced for the subsample with higher political dependency, higher institutional ownership, and more public monitoring.

The next important question is whether regional pollution emergencies bring negative effect on local firms and whether building trust through improving CSR is rewarding. Stakeholders would incorporate regional pollution emergencies as negative information in transactions with local firms and negative judgements are expected to have a series of adverse effects on local firms' production and operation. There has been a tremendous increase in environmentally sensitive investment and lending that attempts to screen firms based on undesirable characteristics such as the amount of pollution, and the probabilities of adverse environmental events. Investors and lenders may attempt to minimize their exposures to negative idiosyncratic event risks, litigation risk and reputation risk by demanding a higher cost of capital or just tilting their portfolios away from firms with environmental weakness (Chava, 2014; Du et al., 2017; Nofsinger et a., 2019). Consistent with this argument, Homroy (2023) shows that British companies with high environmental concerns have higher external financing constraints than companies with low environmental concerns. After the occurrence of extreme pollution emergencies, perceived environmental risks would deter investors and lenders from providing funds, resulting in financing constraints and financial distress. In that case, local firms would face difficulties when finance their investments in productive capacity. Besides, consumers are increasingly focusing on sustainable consumption and consumers who care more about the climate would take firms' environmental weakness into consideration (Sueyoshi and Wang, 2014) and the purchasing intention of environmentally concerned consumers would decrease after regional pollution emergencies. Profitability would be negatively affected due to more difficult financing of its investments and the loss of environmentally concerned consumers.

Godfrey (2005) finds that CSR can also generate moral capital and gain trust from stakeholders, making firms less vulnerable to negative events. If firms successfully build trust with capital providers and other stakeholders by fulfilling their CSR, firms would be less likely to experience financial constraint, financial distress, and decreased performance. Thus, we propose our hypothesis as follows:

Hypotheses 3: local firms experience financing constraints, financial distress and decline in profitability after the extreme regional pollution emergencies. The negative effect could be moderated by improving CSR.

1.3 Data and methods

1.3.1 Data and sample

We collect extreme regional emergency data from China Environment Yearbook, which includes four categories of causes of emergency: corporate pollution discharge, production safety accidents, traffic accidents and others. In this study, we focus on major or particularly major environmental emergencies caused by corporate pollution discharge, since deliberate behaviors are more likely to cause negative stakeholder sentiment than accidental events (Gong et al., 2021). 11 pollution emergencies are considered in this study. The detailed list and information are listed in Appendix 1. A.

CSR performance data are from Hexun website (www.hexun.com). Other firm-level (financial and corporate governance) data are from the CSMAR database. The provincial market development index is from the National Economic Research Institute. Our sample consists of all industrial firms with listed A-shares on either the Shenzhen or Shanghai stock exchange between 2010 and 2017. After excluding firm-year observations with missing data, and observations that receive special treatment (ST), the sample consists of 11,228 firm-year observations.

1.3.2 CSR measures

Hexun website, is the first vertical financial portal and one of the largest financial and securities information service providers in China. Hexun website began to provide CSR scores and ranking data for listed firms in China from 2010. We use two proxies for CSR performance. For a given year, CSR1 measures a firm's total corporate social responsibility score and CSR2 measures the rank of a firm’s CSR performance. A higher score or rank indicates better CSR performance. Compared with other CSR ratings for Chinese firms, such as the RKS rating, which only covers firms that issue CSR reports, one major advantage of using Hexun CSR rating data is that it covers all listed firms because it collects information from both firms' CSR reports and annual reports. Hence, our results are less subject to selection bias.

In addition, Hexun adopts a weighted summation method involving various indicators and discloses detailed individual CSR components. We use these individual CSR components in our study, which include shareholder responsibility (*Shareholder*), employee responsibility (*Employee*), supplier, customer, and consumer responsibility (*Supplychain*), environmental responsibility (*Environment*), and contribution to the society (*Contribution*).

1.3.3 Research design

We use DID method to examine CSR performance changes following extreme regional pollution emergencies. Firms registered in the province with extreme pollution emergencies are identified as the treated firms and the control group consisted of firms registered in the province without extreme pollution emergencies. The DID design offers several advantages. First, it controls for the common trend of both treatment and control groups, which would exist even if no emergencies occurred. Second, given that extreme regional pollution emergencies are exogenous events, it helps us to mitigate the problem that omitted variables drive the emergency-CSR relationship. Third, it captures the dynamic effect, which reflects how firms adjust CSR strategy before and after the emergencies.

$$CSR_{it} = \alpha_0 + \alpha_1 Post_{it-1} + \alpha_2 Controls_{it-1} + Firm\ Fixed\ Effects + Year\ Fixed\ Effects + \varepsilon_{it} \quad (1)$$

where *CSR* is the corporate social responsibility performance for firm i in year t. It is proxied by *CSR1* and *CSR2*. *Post* equals one if the firm-year observation is after the event year, and zero otherwise. We include a set of firm control variables with a one-year lag. Specifically, *Size* is the natural logarithm of total assets. *Leverage* is total debts divided by total assets. *ROA* is net profit scaled by lagged total assets. *TQ* is Tobin's Q, defined as the book value of equity divided by the market value of equity. *Cash* is cash and cash equivalents scaled by total assets. *Inv* is the capital expenditure scaled by lagged total assets. *R&D* is the research and development expenditure divided by total assets. *Age* is the number of years the business has been in existence. *Instown* is the shares held by institutional investors scaled by the total number of shares outstanding. Appendix 1.B shows the detailed definition of variables. We also include firm fixed effects to control unobservable characteristics, which do not change with time. In addition, year fixed effects are also included to consider potential time trend effects and control for any other major economic events that may affect the results. We predict that α_1 should be positive. We argue that following extreme regional pollution emergencies, local firms would strategically improve CSR to build trust among stakeholders.

1.4 Empirical findings

1.4.1 Descriptive statistics

The descriptive statistics of the sample firms are listed in Table 1.1. To reduce the effect of outliers of continuous variables, we winsorize them at the 1st and 99th percentiles. The average *CSR1* is only 25.392 with a maximum value of 100. The mean and median value of the *CSR2* is 2.23 and 2, respectively. This suggests that Chinese listed firms score low in terms of CSR performance and need to improve. The standard deviations of *CSR1* and *CSR2* are 18.262 and 0.66, respectively. The mean value of *Post* is 0.321, this suggests that 32.1% of our sample experienced extreme pollution emergencies.

1.4.2 Extreme regional pollution emergencies and CSR

Table 1.2 reports the regression results of the effect of extreme regional pollution emergencies on the CSR performances of local firms based on model (1). Columns (1) and (3) present the results when *CSR1* is the dependent variable. Columns (2) and (4) present the results when *CSR2* is the dependent variable. As shown in columns (1) and (2), where all control variables are excluded, we find that the coefficients of the key variables of interest, *Post*, are positive and significant (1.728 with t-value = 2.175 and 0.062 with t-value = 2.19). In columns (2) and (4), when control variables are included, the coefficients of *Post* remain positive and significant (1.7 with t-value = 2.341 and 0.062 with t-value = 2.369). The results support our hypothesis *Hypotheses 1a,* indicating that local firms improve CSR performance following extreme regional pollution emergencies. We next check the consistency of the results regarding the effects of other variables in the literature. Consistent with studies on CSR (Liang and Renneboog, 2017; Peng et al., 2023), the relationship between CSR and firm size is positive. CSR is also positively correlated with Tobin's Q and ROA, which supports the view that firms that do better financially can afford CSR (Di Giuli and Kostovetsky, 2014). The negative coefficient of cash ratio is consistent with Jha and Cox (2015). Moreover, the positive role of institutional investors in CSR is also supported by existing literature (Dyck et al., 2019). Some control variables do not obtain statistically significant coefficients, which is mainly because the model controls for firm fixed effects.

CSR is a broad concept covering responsibilities to different stakeholders (Xu and Liu, 2020). In addition, despite industrial industries are broadly regarded as potential sources of pollution, they differ in their pollution levels. This section explores whether firms with different pollution characteristics respond differently to extreme pollution emergencies and whether different CSR sub-indicators share a uniform relationship with the shock of extreme regional pollution emergencies. In particular, we examine five components of CSR, including responsibility to shareholder, employee, supply chain (supplier, customer, and consumer), environment, and society. According to the Guide to Environmental Information Disclosure for Listed Companies [2010] No. 78, we classify all industrial firms into two groups: highly-polluting and non-highly-polluting. Highly-polluting group mainly covers 16 industries, including thermal power, iron, steel, cement, electrolytic aluminum, coal, metallurgy, chemical, petrochemical, building materials, chapter, brewing, pharmaceutical, fermentation, textile, tannery, and mining. To test our *Hypothesis 1b*, we divide our treatment group into highly-polluting and non-highly-polluting groups and run regression separately. We use the integral level and the individual component level of CSR as dependent variables. The results are in Table 1.3.

The results show that for highly-polluting firms, all indices of CSR components increase after extreme regional pollution emergencies, indicating that highly-polluting firms invest in all aspects of CSR. In contrast, non-highly polluting firms do not improve CSR after extreme regional pollution emergencies. The results support our *Hypothesis 1b*. Since highly-polluting firms are more likely to receive unfavorable judgment and suspicion, they are more willing to strategically improve CSR from all aspects to build trust following pollution emergencies.

1.5 Mechanism Analysis and Economic Consequences

1.5.1 Mechanism analysis

This section focuses on *Hypotheses 2* and explore the underlying mechanism through which motive local firms to improve CSR to gain trust after extreme pollution emergencies.

Due to the firm's specific characteristics, firms may face different intensities of external pressures from their stakeholders, which could potentially drive the firm's CSR activities (Gamerschlag et al., 2011; Perez-Batres et al., 2012). As discussed in *Hypotheses 2*, the increase in CSR performance due to extreme regional pollution emergencies may result from three driving factors: political dependency, institutional shareholders, and public monitoring. To further investigate the main reasons for the improvement in CSR performance, we test the underlying mechanisms through which the extreme regional pollution emergencies affect CSR performance.

1.5.1.1 Political dependency

One responsibility of the government is to provide public goods and improve social welfare, for example, reducing pollution. As an additional stakeholder, the government may use politically dependent firms to accomplish its political or social goals (Chen et al., 2018). This is especially true during extreme pollution emergencies. The government should deal with the crisis and stabilize public sentiment, which could lead to greater pressure on politically dependent firms. If this is the case, firms with more political dependency are more likely to improve CSR to respond strategically to political pressure. In this section, we examine how firm's political dependency affects its CSR strategy after extreme pollution emergencies.

Following Chen et al. (2018), we use two measures to proxy the degree of political dependency: state ownership and the level of government subsidies. First, we divide our sample into two groups based on the ultimate ownership. By definition, State-owned enterprises (SOEs) are connected to the government because they are controlled by the government (Lin et al., 2015). A firm is an SOE if its ultimate owner is the government, otherwise it is non-SOE. Consistent with our prediction, the results in Panel A of Table 1.4 show that the coefficients of *Post* for SOEs are positively significant (2.701 with t-value = 2.5 and 0.1 with t-value = 2.891), while the coefficients of *Post* for non-SOEs are not significant. Our findings suggest that, SOEs, with more political dependency, experience a greater improvement in CSR after extreme regional pollution emergencies than non-SOEs.

Second, we divide our sample into two groups based on the government subsidy that the firm received. The amount of government subsidy received by firms reflects the closeness and dependence of their relationship with the government (Jian and Wong, 2010). Based on the median subsidy to total assets ratio for each year, firms are separated into high government subsidy and low government subsidy groups. We conjecture that firms that receive more government subsidies have a closer relationship with the government. As demonstrated in Panel B of Table 1.4, the coefficients of *Post* for high government subsidy firms are positive and significant (1.664 with t-value = 2.207 and 0.073 with t-value = 2.363), while the coefficients of *Post* for low government subsidy firms are insignificant. The results suggest that firms that receive more government subsidies are more willing to invest in CSR after extreme regional pollution emergencies.

1.5.1.2 Institutional shareholders

Previous studies find institutional investors, including those not constrained by socially responsible investment (SRI), avoid stocks exposed to high environmental risks. This is consistent with the prediction of risk management theory (Karpoff et al., 2005; Fernando et al., 2017; Nofsinger et al., 2019). Following extreme pollution emergencies, with the perceived greater environmental risk, institutional investors may adjust their investment decisions, for example, tilting their portfolios away. Pressure from institutional shareholders may “push” local firms to improve CSR.

Based on the median proportion of institutional ownership for each year, we divided the sample into high institutional ownership and low institutional ownership firms. As demonstrated in Table 1.5, for high institutional ownership firms, the coefficients of *Post* for both CSR1 and CSR2 are positive and significant (2.875 with t-value =2.585; 0.113 with t-value=3.078), while the coefficients of *Post* for low institutional ownership firms are insignificant. The results suggest that institutional shareholders are important driver of improved CSR.

1.5.1.3 Public monitoring

Firms evolve within society and their activities affect a wide range of the public. Firms need to legitimize their activities to the public (Cormier et al., 2005). We argue that the

CSR strategy depends on the likelihood of a firm being monitored by the public and the importance the public places on environmental conditions. We posit larger firms, more analyst-followed firms, and firms in regions with a high marketization level have higher level of public monitoring. First, larger firms and more analyst-followed firms have more visibility to public (Etzion, 2007; Nofsinger et a., 2019; Zhong et al., 2018). Thus, larger firms and more analyst-followed firms may be more prone to improve CSR because public may be more aware of their efforts. In addition, in higher level of market development region, the public are more sensitive to, and less tolerant of pollution (Wang et al., 2021). Following pollution emergency, local firms in high marketization region would withstand more public pressure, and then be motivated to put more effort into CSR.

First, based on the median firm size for each year, we divided the sample into big firms and small firms. As demonstrated in Panel A of Table 1.6, for big firms, the coefficients of *Post* for both CSR1 and CSR2 are positively significant (2.07 with t-value =1.816; 0.07 with t-value=1.808), while the coefficients of *Post* for small firms are insignificant. These results suggest that big firms improved CSR after extreme pollution emergencies.

Second, we divide firms into high analyst attention and low analyst attention groups according to the median of the number of analysts following. As shown in Panel B of Table 1.6, for high analyst-followed firms, the coefficients of *Post* for both CSR1 and CSR2 are positively and significant (2.497 with t-value =2.457; 0.096 with t-value=2.56), while the coefficients of *Post* for low analyst attention firms. The results suggest firms with more analysts following improved CSR after extreme pollution emergencies.

Third, we divide the sample into two groups based on the level of marketization of provinces. Fan et al. (2011) constructed an index on the degree of economic development, government intervention, and legal system. It is called “NERI Index of marketization of China's provinces”. Higher scores on the index suggest a higher marketization level. If a firm is in a province with an index reading equal to or above the median value, the firm falls into the high marketization group; otherwise, it belongs to the low marketization group. The results in Panel C of Table 1.6 show the coefficients of the *Post* are significantly positive (1.912 with t-value=2.209 and 0.066 with t-value=2.254) for firms in regions with high level of marketization. However, the coefficients of *Post* for firms in regions with low level of marketization are insignificant.

In sum, based on the results of firm size, number of analysts following, and level of marketization, our results show that public monitoring is a driver of improved CSR after extreme pollution emergencies.

1.5.2 The economic consequences of improved CSR

In this section, we focus on *Hypotheses 3* and analyze the consequence of increased CSR, to confirm if building trust following pollution emergencies is rewarding. As a result of extreme regional pollution emergencies, local firms may be negatively affected because stakeholders perceive local firms as potential polluters and lose trust in them. According to *Hypotheses 3*, local firms may face financial constraint, financial distress, and decreased profitability. From a risk management perspective, CSR could serve as a buffer against stakeholders' negative judgement. CSR activities signal that the firm is not completely self-interested and would take social good into consideration when make decisions. After pollution emergencies, stakeholders may be more tolerant of a firm with a reputation for good CSR and choose to trust them. Thus, firms with increased CSR tend to suffer less. We examine this opinion from the perspective of financing constraints, financial distress, and profitability. We estimate Models (2) to test whether regional pollution emergencies bring negative effect to local firms and whether building trust through CSR is rewarded.

$$
\begin{aligned}
&Oscore_{it},\ KZ\ index_{it}, ROA_{it} \\
&\quad = \alpha_0 + \alpha_1 Post_{it-1} + \alpha_2 Post_{it-1} * IncreasedCSR_i + \alpha_3 Controls_{it-1} \\
&\quad + Firm\ Fixed\ Effects\ + Year\ Fixed\ Effects + \varepsilon_{it} \qquad (2)
\end{aligned}
$$

In Models (2), the dependent variables are financing constraints, financial distress, and firm profitability, which measured by the KZ index[1], the O-score[2] and ROA respectively. Post equals one if the firm-year observation is identified as treat firms after the event year, and zero otherwise. We use a dummy variable to capture the change in CSR after the regional pollution emergency. Comparing the average CSR before and after the regional pollution emergency, if a firm has increased CSR (measured by CSR1) after the emergency, IncreasedCSR equals to 1, and zero otherwise. Control variables are the same as Model (1), and firm and year fixed effects are also included. We adopt a difference-in-difference-in-difference (DDD) design and compare local firms increased CSR after emergencies with other local firms.

As suggested in Table 1.7, the coefficients of Post for O-score and KZ index are positively significant (0.258 with t-value=2.185 and 0.203 with t-value=2.503) and the coefficient of Post for ROA is negatively significant (-0.009 with t-value=-4.344), suggesting that local firms did experience more financing constraints, financial distress and decline in profitability after the extreme regional pollution emergencies. The coefficient of the interaction term between *IncreasedCSR* and *Post* is negatively significant for O-score and KZ index (-0.826 with t-value=-7.877 and -0.787 with t-value=-5.966) and positively significant for ROA (0.025 with t-value=9.547), implying that, proactive CSR strategy helps local firms counteract the negative effects of pollution emergencies. Overall, the results support the *Hypotheses 3*, that is, local firms experience financing constraints, financial distress and decline in profitability after the extreme regional pollution

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[1] Following Kaplan and Zingales (1997), KZ is a composite index of five variables, namely, cash flow $_{it}$/asset $_{it-1}$, leverage $_{it}$, dividend $_{it}$/asset $_{it-1}$, cash holdings $_{it}$/asset $_{it-1}$, and Tobin's Q $_{it}$. Let kz1, kz2, and kz3 equal 1 if cash flow $_{it}$/asset $_{it-1}$, dividend $_{it}$/asset $_{it-1}$, and cash holdings $_{it}$/asset $_{it-1}$ are less than their median, respectively. Let kz4 and kz5 equal 1 if leverage $_{it}$ and Tobin's Q $_{it}$ is larger than their median, respectively. Get KZ = kz1 + kz2 + kz3 + kz4 + kz5, and run the ordered logistic regression of KZ on the five variables using the data of the Chinese listed firms.

[2] The O-score is developed by Ohlson (1980) and measures the likelihood of a firm's bankruptcy, with a higher O-score indicating a higher likelihood of bankruptcy.

The O-Score combines nine accounting ratios into a single statistic:

$$O\text{−}Score=-1.32-0.407SIZE+6.03TLTA-1.43WCTA+0.0757CLCA-2.37NITA-1.83FUTL+0.285INTWO-1.72OENEG-0.521CHIN$$

where SIZE is the log of total asset; TLTA indicates total liabilities to total assets; WCTA indicates working capital to total assets; CLCA indicates current liabilities to current assets; NITA indicates net profit to total assets; FUTL indicates net cash flow from operations to total liabilities; INTWO is a binary variable, equal to 1 if net profit is negative for the past two years, 0 otherwise; OENEG is equal to 1 if total liabilities > total assets, 0 otherwise; CHIN = $(NI_t - NI_{t-1}) / (|NI_t| + |NI_{t-1}|)$, NI indicates net profit emergencies. However, improving CSR helps local firms to moderate the negative effect caused by extreme regional pollution emergencies.

1.6 Parallel Trend and Robust Test

1.6.1 Parallel trend and dynamic analysis

Next, we examine the dynamic relationship between extreme regional pollution emergencies and CSR. We study the difference in CSR between treatment and control groups at different points of time before and after the emergencies to verify the parallel trend and identify the dynamic trend. We do so by replacing the variable *Post* with a set of dummy variables, *d _ i*. For example, variable *d_ 1* equals to 1 for the observations for treatment group and one year after the emergency, and equals to 0 otherwise. variable *d_ -1* equals to 1 for the observations for treatment group and one year before the emergency, and equals to 0 otherwise. The regression coefficient estimated for each dummy variable measures the difference-in-differences in the CSR i (-i) years after (before) the event. This approach allows us to test the parallel trend before the emergencies and identify how long the effect lasts.

The results are shown in Table 1.8. The insignificant coefficients of *d_-3*, *d_-2*, and *d_-1* indicate that the affected and unaffected firms have similar trend in terms of CSR before the extreme regional pollution emergencies, which supports the validity of the DID estimation in this study. The level of CSR begins to increase following pollution emergencies and the effect is persistent. Except *d_ 1* for *CSR1* is insignificant, which may be caused by a lag in impact, the coefficients for other *d_ 1*, *d_ 2* and *d_ 3+* variables are positively significant.

1.6.2 Robustness check

1.6.2.1 Matched sample approach

To test the causal relationship between extreme regional pollution emergencies and CSR, the DID model shown in Eq (1) assumes that control firms provide a good counterfactual to the treated firms. However, there are differences in firm characteristics between the treatment group and the control group before the emergencies. Panel A of Table 1.9 shows that, on average, treated firms have smaller firm size, lower proportion of SOEs, leverage and institutional ownership, higher ROA, cash holding, R&D and capital expenditure. Although we have controlled for firm characteristics in the DID model, the estimation may still suffer from endogeneity problems. We address this problem by using the propensity score matching (PSM) method, which essentially creates a new sample in which the control group firms match the treated group firms in various dimensions. When applying PSM, we first estimate a logit model based on samples before the event in which the dependent variable is a dummy variable that equals one if the firm is in the province with extreme pollution emergencies and zero otherwise and independent variables are all the control variables in Eq (1). The predicted probabilities from the logit model are then used to perform 1:2 nearest-neighbor propensity score matching. As shown in Panel A of Table 1.9, after PSM, the differences in control variables between the treated group and the control group are statistically insignificant which confirms that the matching procedure is successful. Thus, we get two groups of firms that have similar characteristics. The only difference is that the treatment group experiences an extreme pollution emergency and the control group does not. In Panel B, we re-estimate Eq. (1) using the sample after matching. The coefficient of *Post* remains significantly positive which confirms our conclusion. These results help further establish the causal relationship between extreme regional pollution emergencies and CSR.

1.6.2.2. Placebo test

We use a placebo test to check whether the main results are purely driven by chance. Of all the provinces, we randomly select 15 provinces and identify firms located in them as treatment firms, leaving the rest as control firms and randomly choose a year for each treated province as the event year. We repeat the procedure for 1,000 times. We then analyze this simulated sample using the model specifications in Eq (1). Table 1.9 presents the results of the placebo test. For the placebo test of columns (3) and (4) of Table 1.2, the mean value of the coefficients for *Post* is -0.134 and -0.003, with the p-value equal to 0.414 and 0.406, respectively. Fig. 1 shows the distribution of the estimated coefficients for *Post* on *CSR1* and *CSR2,* respectively. Coefficients are distributed around 0 when the treated group and control group are randomly selected, while the coefficients of *Post* in Table 1.2 are 1.7 and 0.062, respectively, which is significantly larger than 0 (as shown by the red vertical line). In other words, based on random treatment firms and control firms and event year, the results of the placebo test are insignificant, suggesting that our previous results may not be driven by chance.

1.6.2.3. Alternative dependent variables

One concern is that *CSR1* is a numerical variable with a maximum value of 100. Its distribution may not be normal. Therefore, we define *Ln CSR1* as the natural logarithm of CSR1 plus 1. In column (1) of Table 1.11, we employ *Ln CSR1* as the dependent variable and the result remains the same.

Another concern is that *CSR1*, is rescaled every year. In this part, we follow the existing CSR chapters by scaling the raw scores by the difference between the maximum scores and the minimum scores of the year. We then run the regression with yearly-adjusted dependent variable. The result, as presented in column (2) of Table 1.11, is qualitatively consist with that in Table 1.2.

1.7 Conclusion

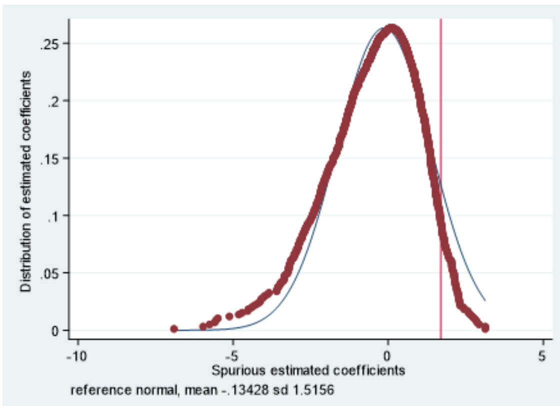
This study investigates the motivation behind CSR strategy following regional pollution emergencies and examines whether the CSR strategy is effective. We propose that CSR can be used to build trust among stakeholders when they have negative sentiments about environmental issues. Taking advantage of the unexpected shock of extreme regional pollution emergencies that lead to sudden increases in stakeholder environmental concerns, we examine the CSR changes after the trust crisis. Specifically, we find that following extreme regional pollution emergencies, the level of CSR activity systematically increases for local firms. Political dependency, institutional ownership and public monitoring are the main drivers of the increased CSR. We also find that firms that spend more on CSR to gain trust do, in fact, receive future rewards in mitigating the decline in performance, financing constraints and financial distress compared with local firms that do not improve CSR. In sum, this study supports that firms engage in CSR not only altruistically but also strategically.

Tables of Figure

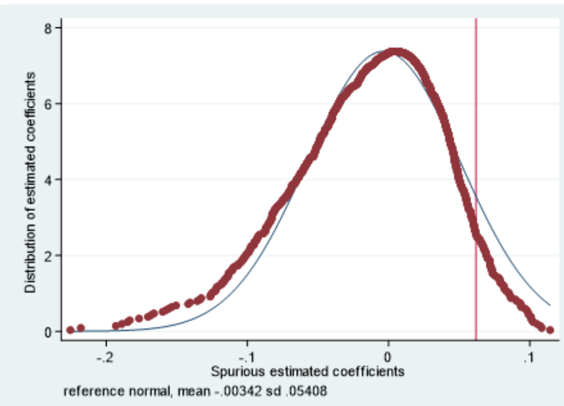
Figure 1.1 Distribution of estimated coefficients for the placebo test

This figure plots point estimated coefficients from placebo test of CSR on randomly assigned treatment group and the time of occurrence of pollution emergencies. Particularly, of all the provinces, we randomly select 15 provinces and identify firms located in them as treatment firms, leaving the rest as control firms and randomly choose a year for each treated province as the event year. Variable *Post* in placebo test is a dummy variable equal to 1 for newly assigned treatment group after the newly arranged event year. We repeat the procedure for 1,000 times and run the regression of equation (1) to get the estimated coefficients of *Post*.

CSR1:



CSR2:



Tables of Results

Table 1.1 Basic statistics

This Table presents the summary statistics of the main variables extracted from *CSMAR* database *and Hexun* website and used in the empirical analysis. Information is provided for number, means, standard deviation, minimum value, p25 value, median, p75 value and maximum value over the period 2010-2017. Definitions of all variables are provided in the Appendix 1. B.

Variables	N	Mean	SD	Min	p25	p50	p75	Max
CSR1	11228	25.392	18.262	-2.920	15.280	20.710	27.595	76.570
CSR2	11228	2.230	0.660	1	2	2	2	4
Post	11228	0.321	0.467	0	0	0	1	1
Control Variables								
Size	11228	21.948	1.218	19.692	21.068	21.766	22.619	25.731
Lev	11228	0.421	0.205	0.048	0.256	0.415	0.581	0.881
Roa	11228	0.041	0.049	-0.117	0.013	0.036	0.066	0.195
TQ	11228	2.752	1.841	0.929	1.526	2.171	3.302	10.943
Cash	11228	0.164	0.129	0.010	0.072	0.127	0.216	0.611
Instown	11228	45.517	24.405	0.340	26.889	48.156	64.749	91.551
Soe	11228	0.409	0.492	0.000	0	0	1	1
Age	11228	14.982	5.019	4.000	11	15	18	28
Inv	11228	0.072	0.074	-0.032	0.023	0.050	0.095	0.410

R&D	11228	2.781	3.117	0	0	2.465	4.140	15.890

Table 1.2 Extreme regional pollution emergencies and integral CSR levels.

This Table examines the effect of extreme regional pollution emergencies on integral CSR levels. The dependent variables in Columns (1) and (3) are firm's total corporate social responsibility score and the dependent variable in Columns (2) and (4) are the rank of a firm's CSR performance (See equation (1)). Columns (1) and (2) exclude control variables and Columns (3) and (4) include control variables. Firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1. B). Standard errors are clustered at the province level and t-values are depicted in parentheses with ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

	(1)	(2)	(3)	(4)
	CSR1	CSR2	CSR1	CSR2
Post	1.728**	0.062**	1.700**	0.062**
	(2.175)	(2.190)	(2.341)	(2.369)
Size			3.341***	0.108***
			(4.984)	(4.381)
Lev			-2.043	-0.036
			(-1.659)	(-0.688)
Roa			44.152***	0.992***
			(8.995)	(4.797)
TQ			0.819***	0.033***
			(5.726)	(6.737)
Cash			-1.094	-0.166**
			(-0.620)	(-2.389)
Instown			0.033*	0.001
			(2.011)	(1.062)
Soe			-0.669	0.063
			(-0.516)	(1.357)
Age			-0.822	-0.010
			(-1.511)	(-0.426)
Inv			1.387	0.024
			(0.379)	(0.179)
R&D			-0.045	0.000
			(-0.497)	(-0.092)
_cons	28.718***	2.330***	-38.929**	-0.039
	(60.473)	(177.283)	(-2.239)	(-0.059)
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	11228	11228	11228	11228
R-squared	0.133	0.118	0.16	0.131

Table 1.3 Extreme regional pollution emergencies and CSR components by different pollution levels

This Table presents the effect of extreme regional pollution emergencies on CSR components by different pollution level. Panel A reports results of the highly-polluting group and Panel B reports results of the non-highly-polluting group. From Column (1) to (7), the dependent variables are firm's total corporate social responsibility score, the rank of a firm's CSR performance, the score in Shareholder responsibility aspect, the score in Employee responsibility aspect, the score in Supply chain responsibility aspect, the score in

Environment responsibility aspect and the score for contribution to the society, respectively. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1. B). Standard errors are clustered at the province level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

Panel A. Highly-polluting firms							
	(1) CSR1	(2) CSR2	(3) Shareholder	(4) Employee	(5) Supply chain	(6) Environment	(7) Contribution
Post	2.889***	0.105**	0.468*	0.394*	0.828**	0.837**	0.342*
	(2.792)	(2.710)	(1.977)	(1.993)	(2.518)	(2.280)	(1.987)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5255	5255	5255	5255	5255	5255	5255
R-squared	0.179	0.152	0.121	0.149	0.162	0.167	0.027
Panel B. Non-highly-polluting firms							
	CSR1	CSR2	Shareholder	Employee	Supply chain	Environment	Contribution
Post	0.161	0.012	0.174	0.087	0.013	0.143	-0.225
	(0.227)	(0.521)	(0.672)	(0.586)	(0.057)	(0.487)	(-1.470)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5973	5973	5973	5973	5973	5973	5973
R-squared	0.147	0.115	0.12	0.101	0.12	0.116	0.018

Table 1.4 Underlying mechanism: political dependency

This Table presents the effect of extreme regional pollution emergencies on CSR of firms with different political dependency. Panel A reports results of subgroup test dividend by ownership of the firm and Panel B reports results of subgroup test dividend by the median amount of government subsidy per firm each year. Column (1) and (2) include the sample of SOE and firms with more government subsidy, which are more dependent on government. Column (3) and (4) include the sample of non-SOE and firms with less government subsidy, which are less dependent on government. The dependent variable in Columns (1) and (3) are firm's total corporate social responsibility score and the dependent variable in Columns (2) and (4) are the rank of a firm's CSR performance. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1. B). Standard errors are clustered at the province level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

Panel A. SOEs versus Non-SOEs				
	SOE		Non-SOE	
	（1）	（2）	（3）	（4）
	CSR1	CSR2	CSR1	CSR2
Post	2.701**	0.100***	0.641	0.030
	(2.500)	(2.891)	(0.846)	(0.827)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	4546	4546	6635	6635

R-squared	0.245	0.212	0.100	0.075

Panel B. High government subsidy firms versus low government subsidy firms				
	High government subsidy		Low government subsidy	
	（1）	（2）	（3）	（4）
	CSR1	CSR2	CSR1	CSR2
Post	1.664**	0.073**	1.776	0.053
	(2.207)	(2.363)	(1.571)	(1.318)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	5612	5612	5616	5616
R-squared	0.147	0.127	0.178	0.146

Table 1.5 Underlying mechanism: Institutional investors

This Table presents the effect of extreme regional pollution emergencies on CSR of firms with different proportion of institutional ownership. Total Sample are divided into two groups by the median amount of proportion of institutional ownership each year. Column (1) and (2) consists of the sample of firms with more institutional ownership. Column (3) and (4) consists of the sample of firms with less institutional ownership. The dependent variable in Columns (1) and (3) are firm's total corporate social responsibility score and the dependent variable in Columns (2) and (4) are the rank of a firm’s CSR performance. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1. B). Standard errors are clustered at the province level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

	High institutional ownership		Low institutional ownership	
	CSR1	CSR2	CSR1	CSR2
Post	2.875**	0.113***	0.220	0.009
	(2.585)	(3.078)	(0.399)	(0.387)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	5612	5612	5616	5616
R-squared	0.223	0.196	0.102	0.074

Table 1.6 Underlying mechanism: Public monitoring

This Table presents the effect of extreme regional pollution emergencies on CSR of firms with different public monitoring level. Panel A reports results of subgroup test dividend by the median level of firms’ total asset each year and Panel B reports results of subgroup test dividend by the median number if analyst followed each year and Panel C reports results of subgroup test dividend by marketization level of each province. Column (1) and (2) include the sample of big firms and firms with high analyst attention and firms in High marketization regions, which face more public monitoring. Column (3) and (4) include the sample of small firms and firms with low analyst attention and firms in low marketization regions, which face less public monitoring. The dependent variable in Columns (1) and (3) are firm's total corporate social responsibility score and the dependent variable in Columns (2) and (4) are the rank of a firm’s CSR performance. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1.B). Standard errors are clustered at the province level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

Panel A. Big firms versus Small firms				
	Big firms		Small firms	

	（1）	（2）	（3）	（4）
	CSR1	CSR2	CSR1	CSR2
Post	2.070*	0.070*	0.624	0.039
	(1.816)	(1.808)	(0.952)	(1.487)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	5612	5612	5616	5616
R-squared	0.250	0.221	0.082	0.050
Panel B. High analyst attention firms versus Low analyst attention firms				
	High analyst attention		Low analyst attention	
	（1）	（2）	（3）	（4）
	CSR1	CSR2	CSR1	CSR2
Post	2.497**	0.096**	0.693	0.034
	(2.457)	(2.560)	(1.303)	(1.675)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	5360	5360	5868	5868
R-squared	0.231	0.213	0.096	0.067
Panel C. Firms in high marketization regions versus Firms in low marketization regions				
	High marketization regions		Low marketization regions	
	（1）	（2）	（3）	（4）
	CSR1	CSR2	CSR1	CSR2
Post	1.912**	0.066**	1.616	0.059
	(2.209)	(2.254)	(1.177)	(1.375)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	8985	8985	2243	2243
R-squared	0.159	0.133	0.185	0.145

Table 1.7 The effectiveness of CSR

This Table exams whether the CSR strategy after the pollution emergencies is effective. The dependent variables are financial distress measured by the O-score, financing constraints measured by the KZ index and the profitability measured by ROA. IncreasedCSR is a dummy variable equals to 1 if the firm has bigger average CSR after the regional pollution emergency compared with the average CSR before the regional pollution emergency, and zero otherwise. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 1. B). Standard errors are clustered at the province level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

	O-score	KZ index	ROA
Post	0.258**	0.203**	-0.009***
	(2.185)	(2.503)	(-4.344)
Post*IncreasedCSR	-0.826***	-0.787***	0.025***
	(-7.877)	(-5.966)	(9.547)
Controls	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes
Observations	11228	10846	11228
R-squared	0.094	0.27	0.089

Table 1.8 Parallel trends and dynamic analysis

This Table examines the evolution of CSR around the pollution emergency event. The model in all specifications is a fixed-effects regression in which the variables of interest are regressed on event-year indicators, d_ k (k = -3, −2, −1, 1, 2, 3+), controlling for firm fixed-effects and year dummies. The indicators equal one for the firm-year observation of the treatment group n-years (n = 1, 2, 3+) before or after the pollution emergency event, and zero otherwise. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 1. B). The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

	CSR1	CSR2
d_-3	-1.343	-0.024
	(-1.485)	(-0.717)
d_-2	-0.802	-0.028
	(-1.074)	(-0.952)
d_-1	0.019	-0.002
	(0.020)	(-0.042)
d_ 1	0.666	0.044*
	(1.173)	(1.767)
d_ 2	1.208*	0.036*
	(1.895)	(1.736)
d_ 3+	3.280**	0.104*
	(2.155)	(2.010)
Controls	Yes	Yes
Firm F. E.	Yes	Yes
Year F. E.	Yes	Yes
Observations	11228	11228
R-squared	0.162	0.132

Table 1.9 PSM-DID

This Table presents the effect of extreme regional pollution emergencies on CSR using PSM-DID method. Panel A is the balancing test. For each control variable, mean values of treated group and control group before and after matching and the bias between treated and control group are presented. Panel B shows the result of DID using matched sample. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 1. B). The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

Panel A: Balancing Test

Variables	Unmatched/Matched	Mean of treated group	Mean of control group	Bias (%)
Size	Unmatched	21.854	22.027	-14.3***
	Matched	21.854	21.842	1
Lev	Unmatched	0.404	0.435	-15***
	Matched	0.404	0.405	-0.2
Roa	Unmatched	0.044	0.038	12.2***
	Matched	0.044	0.044	0
TQ	Unmatched	2.837	2.681	8.5***
	Matched	2.837	2.842	-0.3
Cash	Unmatched	0.167	0.162	4**
	Matched	0.167	0.168	-1

Instown	Unmatched	0.437	0.470	-13.5***
	Matched	0.437	0.436	0.6
Soe	Unmatched	0.328	0.476	-30.5***
	Matched	0.328	0.325	0.6
Age	Unmatched	14.791	15.142	-7***
	Matched	14.791	14.911	-2.4
Inv	Unmatched	0.076	0.068	9.8***
	Matched	0.076	0.074	2.1
R&D	Unmatched	3.033	2.570	14.9***
	Matched	3.033	3.026	0.2

Panel B: DID estimates using matched sample

Variables	CSR1	CSR2
Post	1.478**	0.061**
	(2.295)	(2.526)
Controls	Yes	Yes
Firm F. E.	Yes	Yes
Year F. E.	Yes	Yes
Obs.	9615	9615
R-squared	0.153	0.127

Table 1.10 Placebo tests for the model specifications

This Table presents the result of placebo teat. Particularly, of all the provinces, we randomly select 15 provinces and identify firms located in them as treatment firms, leaving the rest as control firms and randomly choose a year for each treated province as the event year. Variable *Post* in placebo test is a dummy variable equal to 1 for newly assigned treatment group after the newly settled event year. We repeat the procedure for 1,000 times and run the regression of equation (1) to get the estimated coefficients of *Post*. All control variables in main regression, firm fixed effects and year fixed effects are included. For CSR1 and CSR2, the mean value, standard deviation, p25 value, median value and p75 value of coefficient for *Post* and the P-value of the coefficients are presented.

	Mean	SD	P25	Median	P75
CSR1					
Coefficient for *Post*	-0.134	1.517	-1.042	0.106	0.970
P-value for *Post*	0.414	0.305	0.142	0.368	0.664
CSR2					
Coefficient for *Post*	-0.003	0.054	-0.189	0.004	0.105
P-value for *Post*	0.406	0.302	0.000	0.355	0.645

Table 1.11 Alternative dependent variables

This Table presents the effect of extreme regional pollution emergencies on CSR using alternative dependent variables. *LnCSR1* as the natural logarithm of CSR1 plus 1. CSR1-adj is raw scores scaled by the difference between the maximum scores and the minimum scores of the year. All control variables in main regression, firm fixed effects and year fixed effects are included. The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively

	(1)	(2)
	lnCSR1	CSR1-adj
Post	0.059**	0.022**
	(2.102)	(2.376)
Controls	Yes	Yes
Firm F. E.	Yes	Yes
Year F. E.	Yes	Yes
Observations	10971	11228
R-squared	0.094	0.147

Appendix to Chapter 1

Appendix 1. A. Details about extreme regional emergencies caused by corporate pollution discharge

Date of emergency	Name of emergency	Province
08 April 2010	Excessive lead levels in the blood of some children in Guazhou County, Jiuquan City	Gansu
18 October 2010	Thallium levels in the Beijiang River exceeding the standard due to the discharge from the Shaoguan smelter	Guangzhou
08 February 2011	Emission of exhaust gas from "Bangkok Sunshine" bathing center in Zunyi County, Zunyi City, causes the death of three people	Guizhou
05 June 2011	Water quality anomalies in Hangzhou's Campsite	Zhejiang
22 June 2011	Antimony pollution in the Wujiang River	Hunan
13 January 2012	Cadmium pollution in the Long Jiang River	Guangxi
10 November 2013	Diesel contamination at the intake of the Liulinzhou Water Treatment Plant in Jingzhou City	Hubei
26 March 2015	Groundwater contamination in the urban area of Xinhe County, Xingtai City	Hebei
21 October 2015	Poisoning death caused by hazardous waste dumping in Puji Town, Zhangqiu County, Jinan City	Shandong
03 April 2016	Heavy metal levels in Xinyu City's Fairy Lake exceeded the standard, causing the waterworks to stop supplying water	Jiangxi
05 May 2017	The pollution of the Jialing River caused by the discharge of Hanzhong Zinc Company in Ningqiang County	Shanxi (陕西)

Appendix 1. B. Variable definitions

Variables	Definitions
CSR1	Corporate social responsibility score. The better the CSR performance, the higher the score, the full score is 100
CSR2	A firm's corporate social responsibility score. CSR ranks are divided into A to E, and 5 to 1 point are assigned respectively
Shareholder	Score of shareholder responsibility. The better the performance in shareholder responsibility, the higher the score
Employee	Score of employee responsibility. The better the performance in shareholder responsibility, the higher the score

Supply chain	Supply chain (supplier, customer, and consumer rights) responsibility score. The better the performance in supply chain responsibility, the higher the score
Environment	Score of environmental responsibility. The better the performance in environmental responsibility, the higher the score
Contribution	Score of social responsibility contribution. The better the social responsibility contribution, the higher the score
Post	A dummy variable equals one if the firm-year observation is after the extreme pollution emergency, and zero otherwise.
Size	Natural logarithm of total assets
Lev	The ratio of total liabilities to total assets
ROA	Return on total assets, calculated as net profit divided by total assets.
TQ	The ratio of the sum of market value of tradable shares, book value of non-tradable shares and liabilities to book value of total assets
Cash	Cash and cash equivalents scaled by total assets
Instown	Shares held by institutional investors scaled by the total number of shares outstanding
SOE	A dummy variable representing the nature of equity, which equals to 1 for SOEs, 0 otherwise
Age	Firm age, is the number of years the business has been in existence
Inv	Capital investment, calculated as cash payments for fixed assets, intangible assets, and other long-term assets less cash received from selling these assets, divided by lagged total assets
R&D	Research and development expenditure divided by total assets

~ CHAPTER TWO ~
Adding Carrot to Stick: Green Credit, Government Subsidy and High-quality Environmental Innovation

Abstract

We examine to what extent 'policy mix' of green credit policy and government subsidy affects high-quality environmental innovation of high-polluting firms. The green credit policy is a special environmental regulation that guides the distribution of credit from banks. Using the quasi-experiment of the Green Credit Guidelines (GCGs) in China, we find a decline in the level of high-quality environmental innovation of high-polluting firms. However, the negative relationship between GCGs and high-quality Subsidy plays the role of "carrot", effectively correcting the negative impact brought by the "stick" GCGs. The mechanism analysis shows that GCGs hinder high-quality environmental innovation through two channels: (1) increase in compliance costs and (2) lack of long-term bank credit that supports environmental innovation. Government subsidies can play a moderating role in the second channel.

2.1 Introduction

One of China's tremendous economic development side effects is the huge environmental cost. Production activities of firms play a central role in economic growth and are also the main source of environmental pollution. With the awakening of residents' environmental awareness and the longing for a better environment, the transformation and upgrading of high-polluting firms are imminent (Umar et al., 202). Environmental innovation is a cost-effective way to achieve the dual goals of economic development and environmental protection (Rennings, 2000; lv et al., 2021). As a representative of the public interest, the government has social responsibilities committed to guiding firms to be more active in carrying out high-quality environmental innovation through various regulatory and incentive measures. This paper explores the impact of the green credit policy ("stick") on firms' high-quality environmental innovation and the moderating role of the government subsidy ("carrot").

The uniqueness of environmental innovation is reflected in its "double externalities" and "regulatory push/pull effect" (Marchi, 2012; Rennings, 2000). First, as discussed in general innovation literature, innovation has a positive externality: firms invested in innovation and R&D activities cannot fully own the value created due to the knowledge spillover[3]. Second, environmental innovation has an environmental positive externality: part of the benefit of environmental innovation is owned by the society in the form of reduced environmental damage. In addition, firms invested in cleaner technologies bear higher costs than polluting competitors. Due to those externalities, firms lack incentives for environmental innovation. The market failure caused by "double externalities" highlights the role of environmental regulations and government subsidy ("regulatory push/pull effect") (Bi et al., 2016; Huang et al., 2019).

According to Porter and Linde (1995), reasonably crafted environmental regulation should effectively stimulate innovation, which is the intention behind green credit. Green credit is an innovative form of traditional environmental regulation and has become the most widely used green financial instrument in China. As a milestone, Green Credit Guidelines (GCGs)

[3] Knowledge spillovers happens when knowledge is unintentionally shared among individuals, firms, and countries (Fallah and Ibrahim, 2004; Isakksson et al, 2016; Nichloas et al., 2013)

issued in January 2012 marked the standardization and institutionalization of green credit policy. GCGs requires commercial banks to assess firm's environmental risks when granting credit. It aims to restrict the blind expansion of high-polluting industries and guide them to achieve green transition through high-quality environmental innovation (Hu et al., 2021; Nesta et al., 2014). However, GCGs tends to become a paradox and deviate from the initial intention to encourage environmental innovation. The implementation of GCGs is mandatory which means both high-polluting firms and banks need to comply with the regulation. High-polluting firms need to increase investment in pollution control to meet compliance requirements (Jorgenson and Wilcoxen, 1990) which may crowd out investment in environmental innovation. Due to the information asymmetry and the tendency of not violating GCGs, banks tend to decline loans in regulated industries regardless of what the loan is used for (Wen et al., 2021). In addition, because innovation is associated with high uncertainty and banks bear innovation risk but do not share innovation benefits (Stiglitz, 1985; Bhattacharya and Ritter, 1983; Freel, 2007), banks tend to impose stricter credit restrictions on a high-polluting firm actively engaged in innovative activities. The above-mentioned credit discrimination from banks would further reduce high-polluting firms' incentives for environmental innovation.

In addition to forcing green transformation through strict environmental regulations, the Chinese government also offers extensive subsidies to support innovative. In the context of green credit policy, the subsidy has an intermediate role between strict regulation and environmental innovation: First, it may help ease the burden of high compliance costs and act as supplementary funds for research and development (Bronzini and Piselli, 2016; Gao et al., 2021); Second, it may serve as certification signal to help high-polluting firms alleviate bank credit discrimination (Wu, 2017).

Recently, the concept of "Policy Mix" has emerged in dealing with innovation. A policy mix can be defined as the combination of policy instruments, which interact to influence the quantity and quality of R&D investment in public and private sectors. This paper empirically explores the impact of a "policy mix" of GCGs and government subsidy on high-quality environmental innovation. More specifically, this paper uses the difference-in-differences (DID) method to evaluate the impact of GCGs on high-quality environmental innovation. In addition, we also focus on the interaction effect between GCGs and government subsidy. The promulgation of GCGs can be treated as a quasi-natural experiment. Firms with high pollution and high energy consumption are the targets of the GCGs (Liu et al., 2019). Thus, high-polluting firms naturally belong to the treated group and the non-high-polluting firms are the control group. We find that compared with non-high-polluting firms, the GCGs has a negative effect on the high-quality environmental innovation of high-polluting firms. However, government subsidies can moderate the negative relationship between GCGs and high-quality environmental innovation. The moderating effect of government subsidy is more pronounced for the effect of the policy mix is more pronounced for state-owned enterprises (SOEs), firms with political connections, firms in areas with low marketisation, and large firms. Our inferences stay the same after controlling other firm-level determinants of high-quality environmental innovation, such as firm size, Tobin Q, leverage, and cash holding, as well as including firm fixed effect and year fixed effect. The result is robust to alternative sample selections and measurement methods. Mechanism analysis shows that GCGs hinders high-quality environmental innovation through two channels: (1) the increase of compliance costs; (2) the lack of long-term bank credit support for environmental innovation. Government subsidy can play a moderating role in the second channel.

This paper is related to three sets of studies. First, it complements the paper focusing on the impact of green credit policy. Some studies explore the impact of green credit policy on debt financing. Liu et al. (2019) show that the GCGs significantly reduces the ability of high-polluting firms to finance through bank credit. Xu and Li (2020) demonstrate that the green credit policy has a positive and negative impact on the bank credit of green and non-green firms, respectively. In terms of reducing pollution, Sun et al. (2019) suggest green credit policy encourages firms to prevent pollution at source. In terms of industrial upgrading, Wen et al. (2021) find that the GCGs has a negative impact on the upgrading of energy-intensive firms. Liu et al (2017) suggest that the effectiveness of the green credit policy is only manifested in restraining investment in energy-intensive industries, but is relatively ineffective in adjusting the structure of industrial production. Zhang and Vigne (2021) find green credit hinders the performance of high-polluting firms. Environmental innovation is an important mean to coordinate ecology and economy. Whether the green credit policy can encourage high-polluting firms to carry out more high-quality environmental innovation determines the effectiveness of the policy. This paper evaluates the effectiveness of green credit policy from the perspective of high-quality environmental innovation.

Second, green credit policy is an innovative form of environmental regulation and existing literature shows concern for the effect of environmental regulations on firm innovation. In general, there are two different views: One view, according to neoclassical economic theory, environmental regulation would increase compliance costs, squeeze out funds used for R&D, and limit firms' ability to innovate (Gollop and Roberts, 1983; Wagner, 2007). The second view is represented by Porter and Linde (1995), which believes that reasonably designed environmental regulations can incentivize firms to conduct innovation, thus offsetting compliance costs in the long run and achieving a win-win situation. Regarding the impact of regulation on environmental innovation, various environmental regulations, samples, and measurement methods are used, scholars have obtained mixed results including positive relation (Berrone et al., 2012; Brunnermeier and Cohen, 2003), negative relation (Wagner, 2007; Chen et al., 2021). In particular, Nesta et al. (2014) indicate that environmental regulations contribute to the increase of high-quality environmental patents for firms. More related to this paper, Hu et al. (2021) find that green credit policy as an environmental regulation has a positive impact on the environmental innovation of polluting firms. Different from Hu et al. (2021), we take innovation quality into consideration and focus on high-quality environmental innovation. In addition, we are particularly interested in analyzing the interaction effect between GCGs and government subsidy on high-quality environmental innovation.

Finally, on the relationship between government subsidy and innovation, some research believes that government subsidy helps promote innovation by providing funds directly and sending positive signals (Almus and Czarnitzki, 2003; Bianchi et al., 2019; González and Pazó, 2008; Huang et al., 2019; Xie et al., 2019; Li et al., 2021), while some scholars argue that government subsidy crowds out firms' own innovation investment (Boeing, 2016; Marino et al., 2016). Firms receiving government subsidies are more likely to pursue innovation quantity rather than quality to satisfy the government's scrutiny (Dang and

Motohashi, 2015; Jia et al., 2019). In a worse situation, the subsidy is misused in nonproductive rent-seeking activities for obtaining policy inclination (Antonelli and Crespi, 2013). Considering the "policy mix" of environmental regulation and government subsidy, some scholars suggest that government subsidy can compensate for the fund shortage when firms urgently demand environmental innovation to comply with environmental regulations (Bai et al., 2019; Xie et al., 2019). However, Hu et al. (2020) find government subsidy negatively moderates the positive impact of China's carbon emissions trading pilot on firms' innovation.

The study contributes to the literature that examines the effect of environmental regulation on firm innovation behavior. First, this paper enriches the evaluation of the effectiveness of GCGs. The efficacy of GCGs on promoting economic development and environmental protection is determined by whether GCGs can improve high-quality environmental innovation. Compared with the existing literature, where a positive relationship has been found between GCGs and environmental innovation (Hu et al. 2021), we consider only high-quality environmental innovation and found a negative relationship between GCGs and high-quality environmental innovation. Since the intention of GCGs is to promote green transformations of high-polluting firms, we regard high-quality environmental innovation as the true cleaner technologies. In addition, we explicitly examine the channel how GCGs affects high-quality environmental innovation, namely compliance costs channel and bank credit channel. Second, to the best of our knowledge, our paper is the first to empirically examines the interactions between green credit policy and government subsidies. We focus on the role of government subsidy in the context of green credit policy. We find the green credit policy GCGs ("stick") is not effective in stimulating high-quality environmental innovation, but the government subsidy ("carrot") can play an important complementary role to encourage high-quality environmental innovation.

The remainder of this chapter is organized as follows. Section 2.2 discusses the hypotheses, and Section 2.3 describes the research design. Subsequently, Sections 2.4 and 2.5 present the main empirical and robustness test results, respectively. Finally, Section 6 concludes the chapter.

2.2 Hypothesis Development

The green credit policy is an innovative form of environmental regulation, and the existing literature shows concern for the effect of environmental regulations on firm innovation. According to Porter's hypothesis developed by Porter and Linde (1995), properly crafted environmental regulations can effectively stimulate firm innovation. Using various environmental regulations in different countries, scholars have found that the Porter hypothesis holds in the environmental innovation field. Using US manufacturing industries as a research sample, Pickman (1998) found a statistically significant positive relationship between environmental innovation and environmental regulation as measured by pollution abatement and control expenditure (PACE). Based on a novel dataset of 1,566 UK firms, Kesidou and Demirel (2012) provided evidence that stricter regulations are important drivers of eco-innovation. In particular, considering the quality of innovation, Nesta et al. (2014) indicated that environmental regulations contribute to the increase in high-quality environmental patents in OECD countries. Using data on listed firms in China from 2006 to 2020, Du et al. (2022) found a positive relationship between the establishment of monitoring stations and local firms' green innovation. To limit emissions, GCGs cause high-polluting firms to face stricter supervision from the government and greater pressure on credit restrictions from banks. According to the original design of GCGs, high-polluting firms can relieve regulatory pressure and obtain more bank credit through high-quality environmental innovation. Thus, firms are motivated to improve their energy efficiency and environmental protection capabilities in the pursuit of legitimacy (Li et al., 2017). In this regard, GCGs may guide high-polluting firms to conduct high-quality environmental innovation.

However, GCGs might become a paradox and deviate from the initial intention to encourage environmental innovation. According to neoclassical economic theory, environmental regulation increases compliance costs, squeezes out funds used for R&D, and limits firms' ability to innovate, which is a phenomenon known as the 'compliance cost' effect (Gollop and Roberts, 1983; Wagner, 2007). Compared to environmental innovation, investing in pollution abatement facilities has several advantages. Environmental investment can help achieve evident abatement effects in a short time and avoid excessive time input and R&D uncertainty. Chen et al. (2021) found that the carbon emission trading system in China is related to a significant decrease in environmental innovation. As a target of GCGs, high-polluting firms tend to increase investment in pollution control (Jorgenson and Wilcoxen, 1990; Yu et al., 2022), which may crowd out funds for environmental innovation. Owing to this crowding-out effect, the environmental innovation capability of high-polluting firms is weakened. Additionally, GCGs require banks to limit credit to firms with high environmental risks (Liu et al., 2019; Xu and Li, 2020). In practice, banks have difficulty identifying firms' environmental risks. In this case, given the pressure from the government, commercial banks choose to explicitly reduce all credit to high-polluting firms regardless of what the credit is used for (Wen et al., 2021). Innovation is associated with high uncertainty, and banks bear innovation risk but do not share innovation benefits (Stiglitz, 1985; Bhattacharya and Ritter, 1983; Freel, 2007). Therefore, banks impose stricter credit restrictions on high-polluting firms actively engaged in innovative activities. Thus, the innovation capability of high-polluting firms is further weakened. Hence, GCGs might hinder high-quality environmental innovations in high-polluting firms.

Thus, the impact of environmental regulations on environmental innovations may be positive or negative (Du et al., 2021). Whether the Porter hypothesis is true for GCGs depends on how the policy is implemented and how banks and high-polluting firms respond to it. Therefore, we propose the following competing hypotheses:

Hypothesis 1: GCGs have a positive impact on high-quality environmental innovation of high-polluting firms.

Hypothesis 2: GCGs have a negative impact on high-quality environmental innovation of high-polluting firms.

The uniqueness of environmental innovation is reflected in its 'double externalities' (Marchi, 2012; Rennings, 2000). First, as discussed in the general innovation literature, innovation has a positive externality: firms that invest in innovation and R&D activities cannot fully own the value created due to knowledge spillover. Second, environmental innovation has an environmental positive externality; part of the benefit of environmental innovation is owned by society in the form of reduced environmental damage. Additionally, firms investing in cleaner technologies incur higher costs than polluting competitors. Owing to these externalities, firms may lack incentives for environmental innovation. The market failure caused by double externalities highlights the role of environmental regulations and government (Bi et al., 2016; Huang et al., 2019). Therefore, the interaction between GCGs and government subsidies is worth investigating. There are different possibilities regarding the performance of the policy mix of government subsidies and GCGs. The interaction between different policies may lead to positive, negative, or neutral effects (Costantini et al., 2017). The overall effect of a policy mix depends on how the constituent policies interact with each other (Flanagan et al., 2011). If policies are not appropriately coordinated, a policy mix can become a 'policy mess' (Kemp and Pontoglio, 2011). For example, Sorrel and Sijm (2003) found that adding policy instruments to the emission trading system may result in overlapping and conflicting instruments instead of coherence. Hu et al. (2020) found that government subsidies negatively moderate the positive impact of China's carbon emissions trading pilot on firms' innovation. If environmental regulations have played a positive role in stimulating high-quality environmental innovation, the emergence of government subsidies may negatively affect this positive relationship. This is because high-polluting firms can ease credit penalties through high-quality environmental innovation after GCGs. This can also alleviate the financial constraints of high-polluting firms by providing funding directly, and high-polluting firms may lose the incentive to conduct high-quality environmental innovation. Thus, the interaction between GCGs and government subsidies is not conducive to high-quality environmental innovations.

Whether a firm decides to invest in innovation depends on two factors: the incentive to conduct innovation and the capability to raise required funds (Peneder, 2008). A policy mix involving complementary interactions contributes to raising the level of innovation from both 'incentive' and 'capability' aspects (Rogge and Schleich, 2018; Duan et al., 2018). Using a non-parametric matching method, Bérubé and Mohen (2009) found that Canadian plants that benefit from R&D grants and R&D tax innovate more than plants that benefit only from R&D tax. Magro and Wilson (2013) empirically verified the effectiveness of the policy mix of innovation advisory services and innovation vouchers in Italy. Further, applying data from German firms, Greco et al. (2020) found that the combined impact of general innovation and environmental policy instruments on eco-innovation is greater than that of individual policies. Using game theory, Chang et al. (2019a) found that a joint tax subsidy policy can encourage manufacturers to pursue eco-innovation. Under harsh environmental regulations, high-polluting firms are motivated to relieve regulatory pressure through high-quality environmental innovation. However, the huge compliance costs and increased credit discrimination effected by GCGs may cause high-polluting firms to lose their capability for environmental innovation. In this case, the role of government subsidies is highlighted. On the one hand, government subsidies can directly supplement funding for environmental innovation (Almus and Czarnitzki, 2003; Bianchi et al., 2019; González and Pazó, 2008; Huang et al., 2019; Xie et al., 2019; Li et al., 2021). On the other hand, government subsidies have a certification effect (Wu, 2017) and could send a positive signal to banks to moderate their credit discrimination. Thus, government subsidies and GCGs can be combined to contribute to the environmental innovation of high-polluting firms.

Based on the above arguments, the combination of GCGs and government subsidies may have a positive or negative impact on high-quality environmental innovation. Therefore, we propose the following competing hypotheses:

Hypothesis 3: Government subsidies negatively adjust the positive relationship between GCGs and the high-quality environmental innovation of high-polluting firms.

Hypothesis 4: Government subsidies positively adjust the negative relationship between GCGs and the high-quality environmental innovation of high-polluting firms.

2.3 Research Design

2.3.1 Data

GCGs target high-polluting firms; therefore, they are classified as the treated group, and non-high-polluting firms are classified as the control group. Following Zhang et al. (2019a) and Zhang and Vigne (2021), we measure the pollution density of two-digit industry codes one year before the GCGs and identify high-polluting firms according to the industry to which they belong. Four major pollutants were considered: Sulphur dioxide, industrial dust (smoke), solid waste, and industrial sewage. The specific calculation steps are as follows. First, we calculate the per-output pollution emission of each type of pollutant for each industry: $UE_{i,j} = \frac{E_{i,j}}{Output_i}$, where $E_{i,j}$ is the emission of pollutant j in industry i, and $Output_i$ is the gross production value of industry i. Second, the per-output emissions of these four kinds of pollution are linearised and normalised: $UE_{i,j}^{s} = \frac{UE_{i,j} - \min(UE_j)}{\max(UE_j) - \min(UE_j)}$, where $\max(UE_j)$ and $\min(UE_j)$ are the maximum and minimum levels of per-output emission of pollutant j across all industries, respectively. Finally, we calculate the pollution intensity of each industry: $\delta_i = \sum_{j=1}^{n} UE_{i,j}^{s}$. The median of δ_i is 0.184, and we identify high-polluting firms as those in industries with an industry-level δ_i above or equal to 0.184[4].

Green patent data include green patent information on the listed firm, its subsidiaries, associates, and joint ventures. Patent data were collected from the State Intellectual Property Office website. We compared the classification number of patents with the International Patent Classification Green Inventory (IPC-GI)[5] launched by the World International Property Organization (WIPO) to identify green patents. Industry-level pollution emission data were collected from the China Statistical Yearbook on the Environment. The industrial production value data for each industry come from the China Industrial Statistical Yearbook, and the rest of the data are from the CSMAR database. We winsorised the continuous variables at the 1st and 99th percentiles to eliminate the influence of extreme values.

[4] Highly polluting industries include the following: B06. Mining and washing of coal industry; B08. Ferrous metals mining and dressing industry; B09. Non-ferrous metals mining and dressing industry; B10. Non-metallic metals mining and dressing industry; B12. Other mining industries; C13. Agricultural and sideline food processing industry; C14. Food manufacturing industry; C15. Liquor, beverage, and refined tea manufacturing industry; C17. Textile industry; C20. Wood Processing, Timber, Bamboo, Cane, Palm Fibre, and Straw Products industry; C22. Chapter making and chapter product industry; C25. Processing of petroleum; coking; processing of nuclear fuel; C26. Raw Chemical Materials and Chemical Products industry; C27. Pharmaceutical industry; C28. Chemical fiber manufacturing industry; C30. Non-metallic Mineral Products; C31. Smelting and Pressing of Ferrous Metals industry; C32. Smelting and Pressing of Non-ferrous Metals industry; D44. Production and Distribution of Electric and Heat industry

[5] According to the ‘United Nations Framework Convention on Climate Change’, IPC-GI summarises green patents into seven areas: transportation, waste management, energy conservation, alternative energy production, administrative regulatory or design aspects, agriculture or forestry, and nuclear power generation.

Our initial sample includes all industrial firms[6] listed on the Shenzhen or Shanghai Stock Exchange (A-share). Subsequently, we exclude firm-year observations with (1) ST and *ST status, (2) industry change, and (3) missing data. After filtering, we obtain 8,768 observations from 1,602 firms — 730 from the treatment group and 872 from the control group.

2.3.2 Model specification and variable definition

The DID model has advantages in identifying causality; therefore, it is suitable for policy evaluations. This study uses DID to evaluate the effect of GCGs on high-quality environmental innovation and a difference-in-difference-in-difference (DDD) model to evaluate the moderating effect of government subsidies. The models were set as follows:

$$\ln(1+GIP)_{it} = \alpha_0 + \alpha_1 Post_{it-1} + \alpha_2\, Controls_{it-1} + \eta_c + \tau_t + \varepsilon_{it} \qquad (1)$$

$$\ln(1+GIP)_{it} = \alpha_0 + \alpha_1 Post_{it-1} + \alpha_2 Treat_i * Post_{t-1} * Sub_{it-1} + \alpha_3 Sub_{it-1} + \alpha_4\, Controls_{it-1} + \eta_c + \tau_t + \varepsilon_{it} \qquad (2)$$

The independent variables are lagged by one year, relative to the dependent variables; here, *i* represents the firm, and *t* represents the year. $Ln\,(1+GIP)_{it}$ is the natural logarithm of the number of green invention patents applied by firm i in year t plus 1. $Post_{it-1}$ is a dummy variable which equals one for sample if it belongs to the high-polluting industry and after the year of the promulgation of GCG in 2012 and zero otherwise. $Controls_{it-1}$ represents control variables, η_c and τ_t denote the firm and year fixed effects, respectively, and ε_{it} is the error term. Further, coefficient α_1 captures the effect of GCGs on high-quality green innovation, and Sub_{it-1} is measured as the natural logarithm of 1 plus the government subsidy received in year *t-1*. The coefficient of the interaction term $Post_{it-1} * Sub_{it-1}$ captures the moderating effect of the government subsidies.

[6] Firms engaged in mining, manufacturing, and production and supply of electricity, heat, gas, and water are collectively referred to as industrial firms. They are the main sources of energy consumption and pollution emissions.

In terms of measuring environmental innovation, following previous literature (Liu et al., 2021; Ren et al., 2021), we use the number of green invention patent applications (including independent and joint applications) by enterprise groups as a proxy[7]. The Chinese green patent system grants two types of green patents: invention and utility. Green invention patents must undergo rigorous examination. To obtain authorisation, innovation must meet the requirements of 'novelty, creativity, and practicality'. Conversely, green utility patents only need to be different from previously granted patents, and no substantial examination is required. Patents differ significantly in quality (Hirshleifer et al., 2012), especially in China. Firms in China tend to apply for low-quality patents for strategic purposes such as obtaining government subsidies (Dang and Motohashi, 2015). This study focuses on green invention patents that represent high-quality environmental innovation (Hu et al., 2020). In the robustness test, following Hall et al. (2005) and Chen et al. (2021), we used the number of green invention patents granted and forward citations of green patents to measure the level of firms' environmental innovation.

Following prior studies (Liu et al., 2021; Chen et al., 2021; Wen et al., 2021), we added 10 control variables in this study to control the firm-level characteristics that potentially affect firm's high-quality environmental innovation: firm size (Size), listing years (Age), asset-liability ratio (Leverage), return on assets (ROA), growth ability (TQ), cash holdings (Cash), fixed assets ratio (Fixed), ownership concentration (Top1), nature of equity (Nature), and board size (Board). The variable definitions are listed in Appendix 2. A.

2.4 Empirical findings

2.4.1 Descriptive statistics

Table 2.1 presents descriptive summary statistics of the main variables used in this study. Among the 8,768 firm-year observations from 2009 to 2016, the mean of *Ln(1+GIP)* is 0.54, and the median is 0, indicating that the environmental innovation of Chinese firms is still in its infancy. The third quantile of *Ln(1+GIP)* is 0.693, indicating that more than 25% of the firm-year observations have environmental invention patent application records. The

[7] Green patent applications are close to the time of innovation and are a good summary of current environmental technology (Boeing, 2016).

mean for *Post* is 0.295, indicating that 29.5% of the firm-year observations belong to our treatment group, which is a highly polluting firm after the implementation of GCGs. The mean, first quantile, median, and third quantile of the *Sub* were 15.86, 15.12, 16.13, and 17.15, respectively. This indicates that at least 75% of firm-year observations have positive government subsidies. However, there is a large variation in government subsidies. For example, the nominal difference between the first and third quantiles is approximately 24 million RMB. The average *Size*, *leverage*, *TQ*, *Age*, *ROA*, *Fixed*, *Cash*, *Top1*, and *Board* are 21.95, 0.42, 2.45, 1.84, 0.04, 0.27, 0.16, 36.43, and 2.17, respectively, and 44% of firms are SOEs. These statistics are consistent with those in the previous literature.

2.4.2 Main results

Table 2.2 lists the results of Equations (1) and (2), which reflect the impact of GCGs on a firm's environmental innovation level and the moderating effect of government subsidies. The coefficient of *Post* reflects the impact of GCGs on high-polluting firms compared with non-high-polluting firms. As shown in Column (1) of Table 2.2, the coefficient of *Post* is significantly negative (-0.179, *t-value*=-5.13). In Column (2), after adding control variables, the coefficient of *Post* remains significantly negative at the 1% significance level (-0.178 with *t-value*=-5.3). This implies that, compared with non-high-polluting firms, the high-quality environmental innovation of high-polluting firms decreases by 17.8% after GCGs. Our results support Hypothesis 2, which is different from previous studies where a positive relationship between GCGs and environmental innovation is identified (Hu et al, 2021). Once we employ high-quality substantial environmental innovation, we find a negative relationship, indicating that GCGs is not conducive to improving the environmental innovation level of high-polluting firms. Du et al. (2022) discussed the difference between substantial innovation and strategic innovation. Substantial innovation, measured by the number of environmental invention patents, aims to raise the technical level, which is of high quality and requires more and longer investments. Strategic innovation focuses on quantity and speed to meet government scrutiny and set up an image of environmental protection, which can be measured by the number of environmental utility patents. In Columns (3) and (4), the coefficients of the interaction term (*Post* * *Sub*) are significantly positive (0.014 with t-value=2.28, and 0.011 with t-value=1.85). This indicates that government subsidies can mitigate the negative relationship between GCGs and high-quality environmental innovation. Our results support Hypothesis 4. The result demonstrates that the policy mix of GCGs and subsidies helps incentivize high-quality environmental innovation.

The coefficients of the control variables are consistent with the existing literature (He and Tian, 2013; Choi et al., 2011). For example, the bigger, the younger, and more profitable the firm is, and the higher the capital intensity of the firm, the more the firm’s high-quality green patents. An increase in government subsidies has a negative impact on high-quality environmental innovation. One possible reason is that subsidies are misused to pursue innovation quantity and multiple objectives contrary to promoting high-quality innovation (Dang and Motohashi, 2015; Jia et al., 2019; Antonelli and Crespi, 2013; Xia et al., 2022; Guan and Yam, 2015). Firms receiving more government subsidies tend to invest in low-quality innovations with fast output or rent-seeking. This is because such behaviour helps firms obtain more policy preferences and hence receive more government subsidies.

2.4.3 Mechanism analysis: Compliance cost

In this section, we examine whether GCGs hinder environmental innovation by increasing compliance costs. Following Chen et al. (2018), we used a two-step regression approach to conduct the mechanism test. First, we tested the relationship between GCGs and compliance costs. In the second step, we tested the link between compliance costs and high-quality environmental innovation. If GCGs decrease the environmental innovation level by increasing compliance cost, we expect GCGs to positively affect compliance cost in the first-step regression and compliance cost to negatively affect high-quality environmental innovation in the second-step regression. GCGs set a high environmental compliance threshold to obtain bank credit. To obtain bank credit for new projects and continue to obtain credit support for existing projects, firms inevitably need to increase investment in environmental governance, which may crowd out investments in environmental innovation.

Additionally, to test whether government subsidies can moderate the negative impact of GCGs by alleviating the negative impact of high compliance costs on green innovation, we add an interaction term between government subsidies and compliance costs in the second-step regression. If the coefficient of this interaction term is significantly positive, we can conclude that subsidies can effectively mitigate the crowding-out effect of high compliance costs on investment in environmental innovation.

Compliance costs can be proxied by a firm's investment in environmental governance. According to Patten (2005), a firm's environmental capital expenditure is a relatively accurate and objective indicator of its environmental governance. Thus, we use the natural logarithm of a firm's environmental capital expenditure plus one as a proxy for compliance costs, denoted by *LNENV*. Following Zhang et al. (2019b), we manually collected relevant data from construction projects in the firm's annual report. Environmental capital expenditure is the firm's current environmental investment, including sewage treatment, desulphurization equipment upgrades, hazardous waste disposal, and equipment energy-saving renovations.

Table 2.3 presents the results. Panel A presents the first-step regression results. The coefficient of *Post* is significantly positive (0.473 with *t-value*=1.66), indicating that GCGs increase firms' investment in environmental governance. Panel B reports the results of the second-step regression. The coefficient of *LNENV* is significantly negative (-0.00286 with *t-value*=-1.72), indicating a negative relationship between compliance costs and high-quality environmental innovation. The results in Panels A and B demonstrate that GCGs reduce a firm's high-quality environmental innovation by increasing compliance costs. In Panel C, we have no evidence that government subsidy helps alleviate the crowding-out effect of compliance cost as the coefficient of *LNEVN * Sub* is not significant.

2.4.4 Mechanism analysis: Bank credit

In this section, we examine whether GCGs hinder environmental innovation through bank credit channels. First, we tested whether GCGs reduce the bank credit of high-polluting firms. Bank credit was divided into long-term bank credit (*Lcredit*) and short-term bank credit (*Scredit*). We regressed the bank credit variables on *Post*, and the coefficient of *Post* for the long-term bank credit regression was significantly negative (−0.0154 with *t*-

value=−5.06). This indicates that GCGs decrease high-polluting firms' long-term bank credit, while its effect on short-term bank credit is not significant. Even if the bank credit of high-polluting firms is reduced, environmental innovation is not necessarily negatively affected. Studies have shown that internal funding provides support for innovation rather than external funding (Galende and Fuente, 2003). The original intention of GCGs is to penalize high-polluting firms in bank lending to limit their careless expansion and encourage high-polluting firms to conduct environmental innovation, which is effective if banks favor firms with a high level of high-quality environmental innovation (Naqvi et al., 2021).

Inspired by Wen et al. (2021), we investigated the impact of GCGs on credit allocation efficiency. An interaction term between the lag term of the level of high-quality environmental innovation and *Post* was added to the regression. The coefficient of the interaction term (*Post * ln(1+GIP)*) is significantly negative (−0.0053 with *t-value*=−2.39) for the long-term bank credit regression. This suggests that high-polluting firms with a high level of high-quality environmental innovation obtain fewer long-term loans after GCGs. Thus, bank credit does not flow to high-polluting firms with high-quality environmental innovation, which creates inefficiency in credit allocation after GCGs. However, we found no evidence of inefficiency in credit allocation for short-term bank credits.

To further test the moderating effect of government subsidies, we added the interaction item (*Post * ln(1+GIP) * Sub*) in the regression. The coefficient of the interaction term is significantly positive (-0.005 with *t-value*=-2.39) for the long-term bank credit regression, which suggests that government subsidies can alleviate bank credit inefficiency. Again, this effect is not significant for short-term bank credits.

The results, as given in Table 2.4, show the inefficiency of long-term credit allocation of banks. Firms with a high level of high-quality environmental innovation may lack long-term support for innovation activities. Therefore, GCGs restrain high-quality environmental innovation activities via both fewer credit quotas and the mechanism of credit allocation inefficiency. However, government subsidies can act as a certification for firms with a high level of high-quality environmental innovation and help alleviate such credit allocation inefficiency.

2.4.5 Subgroup analysis

To explore the heterogeneity effect of the policy mix of GCGs and government subsidies, we conducted a subgroup analysis from four perspectives: ownership, political connection, degree of regional marketisation, and firm size.

The government will intervene to bail out firms with government guarantee under a situation of financial distress (Boubakri et al., 2012; Dong et al., 2021). Based on government guarantee, the subsidy would send a more positive signal to banks, thereby eliminating credit discrimination. Moreover, firms with government guarantee have comprehensive goals covering economic, environmental, and social benefits. They tend to make good use of government subsidies and make more efforts to conduct high-quality environmental innovation. In this sense, in the context of GCGs, government subsidies help firms with more political connections. As the ultimate controlling shareholder of SOEs is the government, SOEs are more likely to receive government guarantees. In line with our expectation, as Panel A of Table 2.5 shows, the coefficient of *Post * Sub* is significantly positive only for the SOE subsample. Additionally, politically connected managers allow firms to seek government-related benefits and obtain a guarantee. If a firm's Chairman or CEO currently holds a position in the government, we define it as a politically connected firm (Li and Zhang, 2010; Li et al. 2015). The biographical information of CEOs and Chairman is collected from CSMAR database. As Panel B of Table 2.5 shows, the coefficient of *Post * Sub* is significantly positive only for the politically connected subsample.

There are significant differences in the economic development levels and system mechanisms in various regions of China. A developed region typically has more effective local governments and less government intervention than a less-developed region (Firth et al., 2008). A higher degree of local government intervention implies that local officials have a higher level of political power over the local economy, which, in turn, means that government subsidies can provide more guarantees and help release more positive signals. The eastern provinces tend to be more developed than the central or western provinces (Fan et al., 2011). Therefore, following Li and Cheng (2020), we classify firms registered in the eastern coastal provinces as having a high degree of marketisation, while the low marketisation level group is composed of firms located in a central or western province. The results reported in Panel C of Table 2.5 meet expectations; the coefficient of *Post * Sub* is significantly positive only for the subsample with lower marketisation. The results indicate that while GCGs have a negative impact on both the good and low marketisation groups, the policy mix of GCGs and government subsidies is effective for firms in the low marketisation area.

According to the resource-based view (Wernerfelt, 1984), successful innovation depends on a firm's resources and capabilities. Research suggests that large firms outperform small firms in terms of resources and capabilities related to innovation (Shefer and Frenkel, 2005). Small firms may not benefit from the policy mix because they lack a sound foundation for innovation. Firms are divided into large and small groups according to the median firm size in the year of implementation of the GCGs. The results in Panel D of Table 2.5 show that the coefficient of the interaction term *Post * Sub* is significantly positive only for the big firm subsample, which is in line with our expectations.

2.5 Robustness Test

2.5.1 Parallel trend and dynamic effect

A parallel trend is an important premise for using the DID model. We have added *Pre 2*, *Pre 1*, *Pre 2*Sub*, and *Pre 1*Sub* to Equation (1) to verify the parallel trend assumption. *Pre 1* equals 1 for high-polluting firms in 2011 and 0 otherwise. *Pre 2* equals 1 for high-polluting firms in 2010 and 0 otherwise. According to Table 2.6, the coefficients of *Pre 2*, *Pre 1*, *Pre 2*Sub*, and *Pre 1*Sub* are insignificant, and the parallel trend assumption holds. We also add *Post 1*, *Post 1*Sub*, *Post 2*, *Post 2*Sub*, *Post 3*, *Post 3*Sub*, *Post 4*, and *Post 4*Sub*, in which the definition of the time dummy variable is the same as before, to test the dynamic effect of GCGs and government subsidies. The coefficients of these interaction terms are significant, indicating that the impacts of GCGs and government subsidies on high-quality environmental innovation are instant and persistent.

2.5.2 PSM-DID

To test the causal relationship between GCGs, government subsidies, and environmental innovation, the DID model shown in Equation (1) assumes that non-high-polluting firms provide a good counterfactual to high-polluting firms. However, there are differences in firm characteristics between the treatment and control groups before GCGs. Table 2.7 shows the averages of the variables during the pre-GCGs period. High-polluting firms have larger firm size and board size, higher leverage rate, ownership concentration, and fixed asset rate, longer listing years, fewer cash holdings and government subsidies, and higher proportions of SOEs. Although we add them as control variables in our DID model, this may fail to solve the endogeneity problem completely. Following Lu and Wang (2018), we solve this problem using the propensity score matching (PSM) method, creating a new sample in which the control group firms match the treated group firms in various dimensions. When applying PSM, we first estimate a logit model based on samples before the event, in which the dependent variable is a dummy variable that equals 1 if the firm is a high-polluting firm and 0 otherwise. The independent variables are the average values of all the control variables before GCGs. The predicted probabilities from the logit model were then used to perform nearest-neighbor PSM (with no replacement). we use nearest neighbor matching methods to make sure that each treated firm with a control firm has the nearest firm size, listing years, asset-liability ratio, ROA, growth ability, cash holdings, fixed assets ratio, ownership concentration, nature of equity, and board size. As shown in Panel A of Table 2.7, after PSM, none of the differences in the control variables between the treated and control groups is statistically significant, which confirms that the matching procedure is successful. In Panel B, we re-estimate Equations (1) and (2) using the sample after matching. The coefficient of*Post* remains significantly negative, and that of *Post * Sub* remains significantly positive, which confirms our conclusion. These results help further establish the causal relationship between GCGs, government subsidies, and high-quality environmental innovation.

2.5.3 Alternative measures of environmental innovation

In this section, we use two alternative measures of a firm's environmental innovation level. First, patent counts sometimes imperfectly capture the success of innovation. Therefore, we follow Hall et al. (2005) in using the forward citations of a patent to measure its quality or scientific value because other patents tend to cite high-quality patents. Owing to the time effect, there is bias in the use of the original citation data. More specifically, the 2009 patent is cited more than the 2016 patent; the reason may not be higher quality but that it has existed for a longer period. To address this issue, we follow Chang et al. (2019b) and use the fixed effects method, which scales original citation counts by the average citation counts of all green patents applied for in the same year. As shown in Table 2.8, using the natural logarithm of 1 plus the adjusted green patent citation number to measure the high-quality environmental innovation of a firm, we obtain the same result. In other words, GCGs have a negative impact on the level of environmental innovation of high-polluting firms, and government subsidies help mitigate this negative relationship. Second, patent applications may not represent actual technological progress because they may not always be authorized. Patent authorization can reflect the level of innovation to some extent despite the time lag. Thus, we use the natural logarithm of the sum of 1 plus the number of green invention patents granted (*GIP*) as the dependent variable to conduct a robustness test. This result remains the same.

2.5.4 Alternative definition of high-polluting firms

'Guidelines for Environmental Information Disclosure of Listed Firms' promulgated by China Environmental Protection Administration categories 16 industries (these industries include thermal power, iron and steel, cement, electrolytic aluminum, coal, metallurgy, chemicals, petrochemicals, building materials, paper, brewing, pharmaceuticals, fermentation, textiles, tanneries, and mining) as heavy polluting industries. Thus, in this section, we adjust the definition of high-polluting firms. If the firm belongs to these 16 heavily polluting industries, we classify them as the treated group, and generate new variable *POST1* equals 1 for sample in these 16 industries after 2012 and 0 otherwise. The results which shown in Tables 2.9 keep the same. The coefficient of *Post1* is significantly negative (-0.155 with t-value=-4.68), and the coefficient of *Post1 *Sub* is significantly positive (0.011 with t-value=1.79),

2.6 Conclusions and Policy Implications

To promote substantiality and environmental innovation, China implemented GCGs and provided a considerable government subsidy. In this study, we examine to what extent the policy mix of green credit policy and government subsidy affects the high-quality environmental innovation of high-polluting firms. Using the DID method, we find that GCGs negatively impact the high-quality environmental innovation of high-polluting firms in China. Next, we examine the interaction effect of GCGs and government subsidies on high-quality environmental innovation. We find that the policy mix of GCGs and government subsidies is positively related to high-quality environmental innovation. The effect of the policy mix is more pronounced for SOEs, firms with political connections, firms in areas with low marketisation, and large firms. Additionally, we explore why GCGs hinder high-quality environmental innovation. We show that there was an increase in compliance costs for high-polluting firms after the implementation of GCGs and that high compliance costs crowd out high-quality environmental innovation. We also find that bank credit does not flow to high-polluting firms with high-quality environmental innovation, which creates credit allocation inefficiency after GCGs. However, government subsidies can act as a certification for firms with a high level of high-quality environmental innovation and help alleviate credit allocation inefficiency.

In recent years, as the pressure of environmental deterioration mounted, the ‘win-win’ of environmental protection and economic development has received enormous attention. Environmental innovation is a cost-effective way to achieve the dual goals of economic development and environmental protection (Rennings, 2000; lv et al., 2021). Various policy instruments are used to incentivize firms to engage in green innovation. These policies reflect the fact that governments have become highly aware of the crucial environmental situation and importance of environmental innovation. However, the empirical results show some shortcomings in the existing policy design. This study has several implications for policy design. First, the green credit policy should avoid a one-size-fits-all approach. Highly polluting firms actively engaging in environmental innovation should be rewarded with credit. Second, the government needs to provide subsidies to assist green credit policies to improve the level of environmental innovation. Third, more policy instruments could be introduced to interact with other policies and motivate firms to undertake high-quality environmental innovation. Examples include environmental innovation certification and green bonds.

Tables of Results

Table 2.1 Summary statistics

This Table presents the summary statistics of the main variables extracted from *CSMAR* database and State Intellectual Property Office website and used in the empirical analysis. Information is provided for means, standard deviation, minimum value, p25 value, median, p75 value and maximum value over the period 2009 to 2016. Definitions of all variables are provided in the Appendix 2. A.

Variables	Mean	SD	Min	P25	P50	P75	Max
Ln (1+ GIP)	0.543	0.953	0	0	0	0.693	7.058
Sub	15.856	2.784	0.000	15.120	16.128	17.145	20.358
Post	0.295	0.456	0	0	0	1	1
Size	21.944	1.209	19.765	21.066	21.753	22.602	25.706
TQ	2.453	1.540	0.914	1.416	1.978	2.942	9.126
Leverage	0.423	0.201	0.041	0.263	0.423	0.584	0.852
Cash	0.165	0.130	0.010	0.073	0.127	0.218	0.706
Age	1.837	0.884	0.000	1.099	2.079	2.565	3.045
ROA	0.041	0.049	-0.114	0.013	0.036	0.066	0.198
Fixed	0.271	0.155	0.024	0.152	0.238	0.364	0.711
SOE	0.440	0.496	0	0	0	1	1
Top1	36.433	14.776	8.980	24.700	35.100	46.960	75.790
Board	2.172	0.196	1.609	2.079	2.197	2.197	2.708

Table 2.2 Impact of GCGs on high-quality environmental innovation and the moderating effect of government subsidy

This Table examines the effect of GCGs on the level of environmental innovation and the moderating effect of government subsidies. The dependent variables is the natural logarithm of the number of green invention patents applied by firm i in year t plus 1. Columns (1) and (2) exam the effect of GCGs on high-quality environmental innovation and Columns (3) and (4) exam the moderating effect of government subsidies. Columns (1) and (3) exclude control variables and Columns (2) and (4) include control variables. Firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 2. A). Standard errors are clustered at the firm level and t-values are depicted in parentheses with ***, **, *, indicating statistical significance at 1%, 5% and 10% respectively.

Variables	Ln (1+ GIP)			
	1	2	3	4
Post	-0.179***	-0.178***	-0.400***	-0.353***
	(-5.13)	(-5.29)	(-4.27)	(-3.88)
Post * Sub			0.0135**	0.011*
			(2.28)	(1.85)
Sub			-0.00379	-0.008***
			(-1.47)	(-3.16)
Size		0.278***		0.282***
		(7.44)		(7.51)
TQ		0.010		0.010
		(1.25)		(1.24)
Lev		0.084		0.086

		(0.76)		(0.78)
Cash		0.096		0.091
		(0.89)		(0.84)
Age		-0.057*		-0.058*
		(-1.82)		(-1.84)
ROA		0.862***		0.866***
		(3.98)		(4.03)
Fixed		0.203**		0.206**
		(1.98)		(2.02)
SOE		0.083		0.082
		(0.69)		(0.69)
TOP1		0.003		0.003
		(1.39)		(1.4)
Board		-0.0292		-0.028
		(-0.4)		(-0.39)
Constant	0.204***	-5.921***	0.260***	-5.894***
	(8.25)	(-7.24)	(6.37)	(-7.2)
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	8768	8,768	8,768	8,768
R^2	0.106	0.128	0.106	0.129

Table 2.3 Mechanism analysis: compliance cost

This Table exams whether GCGs hinder environmental innovation by increasing compliance costs and the moderating effect of government subsidies. Panel A shows the result of the regression of LNENV on Post, Panel B shows the result of the regression of ln (1+ GIP) on LNENV, and Panel C explores the moderating effect of government subsidies. LNENV is the natural logarithm of a firm's environmental capital expenditure plus one. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 2. A). Standard errors are clustered at the firm level and t-values are depicted in parentheses with ***, **, *, indicating statistical significance at 1%, 5% and 10% respectively.

Panel A: regression of LNENV on Post		Panel B: regression of ln (1+ GIP) on LNENV		Panel C: moderating effect of government subsidy	
Variables	LNENV		Ln (1+ GIP)		Ln (1+ GIP)
Post	0.473*	LNENV	-0.003*	LNENV	-0.0003
	(1.66)		(-1.71)		(-0.06)
				LNENV*Sub	-0.0002
					(-0.42)
Controls	Yes	Controls	Yes	Controls	Yes
Firm F. E.	Yes	Firm F. E.	Yes	Firm F. E.	Yes
Year F. E.	Yes	Year F. E.	Yes	Year F. E.	Yes
Observations	8,768	Observations	8,768	Observations	8,768
R^2	0.005	R^2	0.123	R^2	0.123

Table 2.4 Mechanism analysis: bank credit

This Table presents the impact of GCGs on firms' high-quality environmental innovation and the moderating effect of government subsidies through long-term and short-term bank credit. The dependent variable in Panel A is long-term bank credit, which is the ratio of long-term loan to total assets, The dependent variable in Panel B is short-term bank credit, which is the ratio of short-term loan to total assets, All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 2. A). Standard errors are clustered at the firm level and t-values are depicted in parentheses with ***, **, *, indicating statistical significance at 1%, 5% and 10% respectively.

Variables	Panel A: Long-term bank credit Lcredit			Panel B: Short-term bank credit Scredit		
Post	-0.015***	-0.013***	0.017**	-0.005	-0.006	-0.01
	（-5.06）	（-4.14）	（2.01）	（-1.31）	（-1.41）	（-1.58）
ln (1+ GIP)		0.00182	0.00578**		0.00297*	0.000367
		(1.461)	(2.043)		(1.709)	(0.127)
Post * ln (1+ GIP)		-0.005**	-0.027**		0.002	0.012
		（-2.39）	（-2.03）		（0.86）	（1.4）
ln (1+ GIP) * Sub			-0.000242			0.000157
			(-1.529)			(1.097)
Post * Sub			-0.00189***			0.000696
			(-3.504)			(1.121)
Post * ln (1+ GIP) * Sub			0.001*			-0.001
			（1.75）			（-1.16）
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,768	8,768	8768	8768	8768	8768
R2	0.076	0.078	0.08	0.102	0.103	0.103

Table 2.5 Subgroup analysis

This Table presents the impact of GCGs and government subsidies on firms' high-quality environmental innovation considering firms' ownership, political connection, degree of regional marketisation, and size. Panel A reports results of subgroup test dividend by firms' ownership; Panel B reports results of subgroup test dividend by whether firm is political connected; Panel C reports results of subgroup test dividend by marketization level of each province; Panel D reports results of subgroup test dividend by the median level of firms' total asset each year. All control variables in main regression, firm and year fixed effects are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 2. A). Standard errors are clustered at the firm level and t-values are depicted in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

Panel A: SOEs vs. non-SOEs

Variables	Ln (1+ GIP)			
	SOEs		non-SOEs	
Post	-0.199***	-0.588***	-0.184***	-0.041
	(-3.68)	(-3.63)	(-4.72)	(-0.49)
Post * Sub		0.023**		-0.009
		(2.39)		(-1.59)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	3,828	3,828	4,906	4,906
R^2	0.163	0.167	0.099	0.099

Panel B: With political connection vs. Without political connection

Variables	Ln (1+ GIP)			
	With political connection		Without political connection	
Post	-0.170***	-0.410 ***	-0.177***	-0.295**
	(-3.12)	(-3.21)	(-4.06)	(-2.42)

Post * Sub		0.015*		0.007
		(1.74)		(0.94)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	3,624	3,624	5,144	5,144
R^2	0.134	0.137	0.128	0.129

Panel C: High degree of marketisation vs. low degree of marketisation

Variables	Ln (1+ GIP)			
	Low marketisation		High marketisation	
Post	-0.148***	-0.402***	-0.193***	-0.278*
	(-2.64)	(-4.62)	(-4.49)	(-1.74)
Post * Sub		0.016***		0.005
		(2.99)		(0.5)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	3,220	3,220	5,548	5,548
R^2	0.122	0.124	0.139	0.14

Panel D: Big firms vs. Small firms

Variables	Ln (1+ GIP)			
	Big firms		Small firms	
Post	-0.196***	-0.517***	-0.167***	-0.068
	(-4.14)	(-2.88)	(-3.91)	(-1.06)
Post * Sub		0.019*		-0.007
		(1.76)		(-1.63)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	4,911	4,911	3,857	3,857
R^2	0.158	0.16	0.09	0.09

Table 2.6 Parallel trend and dynamic effect

This Table examines the evolution of high-quality environmental innovation around the GCGs and moderating effect of government subsidy. The model in all specifications is a fixed-effects regression in which the variables of interest are regressed on event-year indicators, controlling for firm fixed-effects and year dummies. The *Pre "n"* and *Post "n"* indicators equal one for the firm-year observation of the treatment group n years before or after the GCGs, and zero otherwise. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 2. A). The t-statistics based on standard errors clustered at the firm level are reported in parentheses. ***, **, and * indicate that the coefficients are significant at the levels of 1%, 5%, and 10%, respectively.

Variables	Ln (1+ GIP)
Pre 2	-0.159
	(-1.55)
Pre 2 * Sub	0.004
	(0.63)
Pre1	-0.16
	(-1.55)
Pre1 * Sub	-0.002
	(-0.37)
Current	-0.230**
	(-2.35)
Current * Sub	0.003

	(0.47)
Post 1	-0.416***
	(-4.32)
Post 1 * Sub	0.011**
	(1.98)
Post 2	-0.378***
	(-2.77)
Post 2 * Sub	0.004
	(0.44)
Post 3	-0.622***
	(-4.35)
Post 3 * Sub	0.018**
	(2.1)
Post 4	-1.035***
	(-5.31)
Post 4 * Sub	0.037***
	(3.18)
Controls	Yes
Firm F. E.	Yes
Year F. E.	Yes
Observations	8,768
R^2	0.135

Table 2.7 PSM-DID

This Table presents the effect of GCGs on firms' high-quality environmental innovation and the moderating effect of government subsidies using PSM-DID method. Panel A is the balancing test. For each control variable, mean values of treated group and control group before and after matching and the bias between treated and control group are presented. Panel B shows the result of DID using matched sample. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 2. A). The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

Panel A: Balancing test

Variables	Unmatched/Matched	Mean of treated group	Mean of control group	Bias (%)
Sub	Unmatched	15.129	15.451	-11.5*
	Matched	15.335	15.247	3.2
Size	Unmatched	21.886	21.492	34.8***
	Matched	21.547	21.538	0.8
Lev	Unmatched	0.44	0.38	29.8***
	Matched	0.4	0.388	6.1
TQ	Unmatched	2.423	2.376	3.8
	Matched	2.403	2.512	-8.9
Age	Unmatched	1.681	1.259	41***
	Matched	1.413	1.386	2.7
ROA	Unmatched	0.049	0.05	-2.5
	Matched	0.05	0.053	-7.9
Fixed	Unmatched	0.326	0.2	90.9***
	Matched	0.251	0.248	2.8
Cash	Unmatched	0.174	0.24	-43.7***
	Matched	0.206	0.212	-4
SOE	Unmatched	0.561	0.367	40***
	Matched	0.439	0.424	3
TOP1	Unmatched	38.623	36.619	13.5**

	Matched	36.184	37.392	-8.1
Board	Unmatched	2.22	2.165	30.2***
	Matched	2.183	2.183	0

Panel B: DID and DDD estimates using matched sample

Variables	Ln (1+ GIP)	Ln (1+ GIP)
Post	-0.181***	-0.435***
	(-4.99)	(-3.15)
Post * Sub		0.016*
		(1.72)
Controls	Yes	Yes
Firm F. E.	Yes	Yes
Year F. E.	Yes	Yes
Observations	5186	5186
R^2	0.166	0.166

Table 2.8 Alternative measures of environmental innovation

This Table shows the effect of GCGs on firms' environmental innovation levels and the moderating effect of government subsidies using alternative measures. The dependent variable *ln (1+ CITA)* is natural logarithm of 1 plus the adjusted green patent citation number. The dependent variable *ln (1+ GGIP)* is natural logarithm of 1 plus the number of green invention patents granted. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 2. A). The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

Variables	Ln (1+ CITA)		Ln (1+ GGIP)	
Post	-0.276***	-0.861***	-0.079***	-0.237***
	(-6.29)	(-8.53)	(-2.89)	(-3.54)
Post * Sub		0.036***		0.010**
		(5.79)		(2.2)
Controls	Yes	Yes	Yes	Yes
Firm F. E.	Yes	Yes	Yes	Yes
Year F. E.	Yes	Yes	Yes	Yes
Observations	8,768	8,768	8,768	8,768
R^2	0.398	0.405	0.078	0.079

Table 2.9 Alternative definition of high-polluting firms

This Table shows the effect of GCGs on firms' environmental innovation levels and the moderating effect of government subsidies using alternative definitions for high-polluting firms. Post1 is a dummy variable equal 1 for highly-polluting firms according to 'Guidelines for Environmental Information Disclosure of Listed Firms' promulgated by China Environmental Protection Administration after the release of GCGs, and zero otherwise. All control variables in main regression, firm fixed effects and year fixed effects are included. Definitions of control variables are provided in the Appendix (Annex 2. A). The t-statistics based on standard errors clustered at the province level are reported in parentheses. ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

Variables	Ln (1+ GIP)	
Post1	-0.155***	-0.331***
	(-4.68)	(-3.4)
Post1 * Sub		0.011*
		(1.73)
Controls	Yes	Yes
Firm F. E.	Yes	Yes
Year F. E.	Yes	Yes
Observations	8,768	8,768

R^2	0.126	0.127

Appendix to Chapter 2

Appendix 2. A Variable definitions

Variables	Symbols	Definitions
High-quality green innovation	Ln (1+ GIP)	Natural logarithm of 1 plus the number of green invention patents applied by a firm in a year (Log)
Government subsidy	Sub	Natural logarithm of 1 plus the government subsidy received by the firm of the period (Log)
Green credit policy	Post	A dummy variable equals 1 for high-polluting firms in or after 2012, and 0 otherwise (Dummy)
Firm size	Size	Natural logarithm of total assets (Log)
Asset-liability ratio	Leverage	Ratio of total liabilities to total assets (%)
Growth ability	TQ	Ratio of the sum of market value of tradable shares, book value of non-tradable shares, and liabilities to book value of total assets (%)
Listing years	Age	Natural logarithm of the number of years since listing (Log)
Return on assets	ROA	Return on total assets (%)
Fixed assets ratio	Fixed	Ratio of fixed assets to total assets (%)
Cash holdings	Cash	Ratio of the balance of cash and cash equivalents to total assets (%)
Nature of equity	SOE	A dummy variable representing the nature of equity, which equals 1 for SOEs and 0 otherwise (Dummy)
Ownership concentration	Top1	Shareholding ratio of the largest shareholder (%)
Board size	Board	Natural logarithm of the number of directors (Log)
Environmental investment	LNENV	Natural logarithm of 1 plus firm’s environmental capital expenditure (Log)
Long-term bank credit	Lcredit	Ratio of long-term loan to total assets (%)
Short-term bank credit	Scredit	Ratio of short-term loan to total assets (%)

Appendix 2. B Additional tests on Market reacts of the promulgation of GCGs

When firms are pressured to take action to control pollution, environmental compliance should not be expected to be profitable and regulatory costs are drain on a firm's resources which can reduce firms' productivity and competitiveness. Investors may not appreciate the environmental policy because they interpret it as imposing a significant cost on the firm and, if they perceive the unduly costs are greater than benefits, they may assign a lower valuation to complying firms. In this section, we implement an event study method to investigate whether the market reacts when the GCGs is first promulgated. GCGs was promulgated on January 29, 2012. Because of the Spring Festival holiday, neither the promulgation date nor the previous week was a trading day, so we calculate the cumulative abnormal return (CAR) in different windows after the promulgation date. To get market abnormal returns, we first estimate the expected returns, using the market model and the estimation window [−110, −10]. Abnormal return is the firm's stock return minus the expected return. According to Table Appendix 2. B, the CARs are significantly negative after the implementation of GCGs for highly polluting firms. For non-polluting firms, there is a no significant cumulative return. The difference between highly polluting and non-highly pollution firms is significant across most event windows.

Table Appendix 2. B Between-group analysis of CARs

This table provides cumulative abnormal returns pertaining to GCGs and compare the difference of market reaction of Highly polluting firms and non-highly polluting firms. Date 0 is the promulgation date of the GCGs. the event study is based on market model and the estimation window [−110, −10]. the cumulative abnormal return 1 to 5 days after the GCGs is presented. For highly polluting firms and non-highly polluting firms, number of observations, mean value of CSR, t ratio and p value are shown respectively and the last column shows the difference of mean value between the two group. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

CAR	Highly polluting firms				Non-highly polluting firms				
	N	Mean	T ratio	P value	N	Mean	T ratio	P value	Diff
[0,1]	682	-0.00157**	-2.3	0.022	787	0.000667	1.13	0.26	-0.00224**
[0,2]	682	-0.00247**	-2.38	0.017	787	-0.00078	-0.84	0.401	-0.00169
[0,3]	682	-0.00333**	-2.52	0.012	787	-0.000115	-0.1	0.921	-0.00321**
[0,4]	682	-0.00341**	-2.42	0.016	787	-0.00079	-0.59	0.555	-0.00262
[0,5]	682	-0.00553**	-3.37	0.001	787	0.00212	1.33	0.183	-0.00766***

~ CHAPTER THREE ~
Political Corruption and Stock Liquidity

Abstract

We examine whether political corruption impedes stock liquidity. Using a comprehensive sample of listed firms in China, we find that political corruption has a negative effect on local stock liquidity. Our identification strategy exploits instrument variable and quasi natural experiment of anticorruption regulation that reduce firms' exposure to political corruption. Political corruption affects stock liquidity through information and investors' trading activity channels. Because of increased stock illiquidity, firms located in highly corrupt areas are associated with higher costs of equity and more reliance on short-term debt. Our results highlight the negative externalities of political corruption on the financial market.

3.1 Introduction

In the realm of the dynamic financial market, the significance of liquidity, a fundamental component of financial markets, remains a focal point for researchers, firms, investors, and regulators (Stiglitz, 1981; Sadka and Scherbina, 2007; Chordia et al., 2008; Goyenko et al., 2009; Næs et al., 2011). This interest is particularly pronounced in the context of China's stock market, where liquidity not only underpins financial stability but also emerges as a pivotal predictor of stock returns, as highlighted by Leippold et al. (2022). Yet, being a dominant emerging economy that experienced unprecedented economics and stock market expansions, the persistent specter of political corruption introduces a layer of complexity. Extensive literature has documented the detrimental impact of political corruption on economic development, emphasizing its role in distorting resource allocation, undermining competition, and hindering productivity growth (Murphy et al., 1993; Shleifer and Vishny, 1993; Mauro, 1995; Fisman and Miguel, 2007). Beyond these macroeconomic implications, political corruption’s reach extends into business environments, influencing firm-specific decision making (DeBacker et al., 2015; Smith, 2016; Liu, 2016; Huang and Yuan, 2021). However, while these macroeconomic insights are established, a conspicuous gap exists in the literature—a dearth of detailed evidence on the specific impact of political corruption on stock liquidity.

There are two primary mechanisms through which political corruption can affect firm’s secondary-market liquidity: altering the stock trading activity and changing firms’ information environment. First, political corruption is likely to be related to lower levels of trust in the local economy and local firms potentially linked to corruption. The increase of investors’ perceived probability of being cheated could negatively affect their willingness to assume financial risk and participate in stock market (Bu et al., 2022). We hypothesize that political corruption could impede market liquidity by decreasing the investor base and related trading activity, since reduced trading activity typically leads to diminished liquidity and less efficient securities transactions (Benston and Hagerman, 1974; Stoll, 2000). Second, information asymmetry problems are prevalent in corrupt environments. A characteristic feature of corruption is its illegality, and consequently, its secrecy (Shleifer and Vishny, 1993). Firms located in corrupted regions would adopt more secrecy to mask their rent-seeking (Dass et al., 2016). Less transparency can obscure undercurrents of private knowledge and trading on private information (Gul et al., 2010; Diamond, 1985). Uninformed traders are concerned about the potential losses of trading against informed traders, leading them to increase spreads (an adverse selection effect), which impairs liquidity.

To investigate the association between political corruption and stock liquidity, we exploit the variations in the corruption environments among provinces in China. Following prior literature, we use the number of corruption convictions per 10,000 people as a proxy for province-level corruption, where a larger number indicates a higher corruption rate (Glaeser and Saks, 2006; Butler et al., 2009; Bu et al., 2022). The empirical evidence suggests that firms in more corrupt provinces tend to have lower level of stock liquidity. This relation is statistically and economically significant. Cross-sectional tests suggest the impact of local political corruption on stock liquidity is more pronounced for firms that are more reliant on political favors and/or corruption-prone. In particular, those firms are private firms and local state-owned enterprises controlled and firms in less developed areas. However, the positive relationship between political corruption and stock illiquidity may be subject to endogeneity concerns. First, the results may be driven by omitted province-level factors that correlate with both the level of local corruption and stock illiquidity. For instance, better local economy is associated with lower corruption (Glaeser and Saks, 2006) and better liquidity levels of local stocks (Bernile et al., 2015). Second, the choice of a firm's registration location could be endogenous. Because registration locations are not randomly assigned, firms could choose to locate in areas with different levels of political corruption and this selection could be correlated with stock liquidity. To rule out these concerns and identify the causal effect of political corruption on stock liquidity, we propose several identification strategies that exploit exogenous sources of variation in political corruption. Firstly, we control for firm and year fixed effects in regressions to account for omitted variables vary over time but not across firms and time-invariant firm-specific omitted variables. Secondly, we apply propensity score matching (PSM) method to balance characteristics between firms in high- and low-corruption provinces. Thirdly, we employ a novel Bartik-style instrumental variable (IV) that combines changes in levels of corruption by year and the local historical dishonest behaviors during Great Leap Forward period (late

1950s). Instrumented corruption is positively and significantly related to stock illiquidity, and the result is economically significant. Finally, we exploit anticorruption regulation released in China, which is an exogenous shock to the possibility of firms being involved in corruption. Our findings reveal that following this regulation, which mandates bureaucrats to forcibly resign from independent director roles, stock liquidity improves in firms that previously had bureaucrats as independent directors. Our results are consistent across all these approaches which increases confidence in our interpretation that corruption has a causal and negative impact on stock liquidity. Moreover, the results are also robust to use alternative measures of corruption and stock liquidity.

Mechanism analysis suggests that political corruption affects liquidity through both trading activity and informational asymmetry. Specifically, we test whether political corruption impedes trading activity and increases informational asymmetry, which in turn constrains stock liquidity. We first document that political corruption results in a reduction of investor base and related trading activity (as measured by the number of shareholders, stock turnover and the number of trades per day following Ng et al. (2016) and Ding and Hou (2015)), and lower level of trading activity is negatively associated with stock liquidity. Similarly, we find that political corruption induces information asymmetry (as measured by firm's KV index following Kim and Verrecchia (2001) and probability of information-based trading following Easley et al. (2012)), and increased information asymmetry leads to lower stock liquidity. As illiquidity can affect firms' ability to raise capital, further analysis shows that stock illiquidity caused by higher political corruption increases reliance on short-term debt financing.

This study makes several contributions to the literature. First, we add to the literature on the determinants of stock market liquidity. Broadly, studies have focused either on firm-level characteristics (Brockman et al., 2009; Ng, 2011; Pham, 2020) or on stock market structure (Christie and Huang, 1994) to explain stock liquidity. Several papers document that stock liquidity can be affected by institutional features such as investor protection laws (Chung, 2006), policy uncertainty (Nagar, 2019) and a country's overall macro-level political institutions (Eleswarapu and Venkataraman, 2006). Our study adds to the literature by considering political corruption as another important institutional factor in stock liquidity.

We also contribute to the research on the effect of corruption. Because of survey data availability, extensive research on corruption focuses on international settings (Wu, 2006; Barkemeyer et al., 2018; Ferris et al., 2021). Fisman and Gatti (2002) note, however, that within-country studies have an advantage in controlling for institutional (e.g., investor protection) and cultural (e.g., attitudes toward corruption) differences at the national level. Further, compared with developed countries, typically with low corruption, China characterized by widespread corruption provides an ideal setting to study the effect of corruption. Based on Chinese background, there has been a growing literature study the effects of corruption and anticorruption campaign on the economy and financial markets, such as efficiency of capital and labor allocation (Giannetti et al. 2021), corporate social responsibility (Hao et al., 2020; Xue et al., 2022), price discount in land transactions (Chen and Kung, 2019), innovation (Xu and Yano, 2017; Fang et al., 2022), corporate investment (Pan and Tian, 2020), stock price crash risk (Chen et al., 2018) and firm value (Xu, 2018). We contribute to existing literature primarily by documenting the adverse effects of corruption on stock market liquidity.

In addition, our use of Bartik-style instrumental variable that combines changes in levels of corruption by year and the local historical dishonest behaviors during Great Leap Forward period represents a methodological contribution, as this approach helps address the endogeneity issues. Furthermore, by empirically assessing the effectiveness of anticorruption campaign by President Xi Jinping, our paper contributes to a growing literature devoted to examining the design of political institutions in curbing corruption.

The remainder of the paper proceeds as follows. Section 3.2 develops the main hypothesis. Section 3.3 describes our sample and research design. We present our main empirical results and additional test results in Sections 3.4 and 3.5, respectively. Section 3.6 concludes.

3.2 Hypothesis development

Although the Chinese economy is transforming into a highly market-oriented model, the government still exerts considerable influence over the market. Governments are extensively involved in economic activities and control the allocation of scarce resources, such as land, bank loans, energy, and raw materials (Cull and Xu, 2005). Dense networks of guanxi ("connections") have historically and culturally been deep-rooted in China. When such interpersonal obligations become excessive, they can turn into political corruption. In China, corruption has been an increasing concern. We conjecture that the political corruption affects stock liquidity through the following channels.

Firstly, political corruption can affect stock liquidity through the impact on the level of investor participation. Corrupt practices, such as bribery, extortion, and public officials' rent extraction, make investors perceive a higher probability of dishonesty and being cheated. In addition, the legal rules that protect investors from expropriation cannot be enforced fairly by corrupt governments, which weakens investors' willingness to participate in equity markets (Porta et al., 1998; Eleswarapu and Venkataraman, 2006). Further, the incidence of conviction event itself could be considered an unavoidable source of risk for many investors, increasing the perceived risk of stock market, and decreasing investors' participation. Investor participation and their trading activity is an important factor related to stock liquidity. Stoll (2000) refers to the reduction in liquidity related to investor participation as a real friction effect that is defined as "the real resources used up" in the liquidity-provision process. Decreased investor participation and trading frequency in the stock market results in fewer trades, thereby escalating fixed transaction costs and consequently diminishing stock liquidity (Brockman et al., 2009).

Secondly, political corruption could reduce stock liquidity by disrupting the information environment. High-quality information disclosure is fundamental to the development of financial markets, which could mitigate the information asymmetry between investors (Healy and Palepu, 2001; Balakrishnan et al., 2014; Nagar et al., 2019). However, political corruption is related to low level of information disclosure. On the one hand, corrupt environment allows firms to gain access to preferential financing through bribery and external investors may be attached with lower importance. As a result, firms have reduced incentives to provide high-quality information disclosure. On the other hand, preferential treatment and better political protection gains through bribery are in the gray area or of dubious legality (Fisman, 2001). Therefore, insiders may want to reduce transparency to mask their rent-seeking activities (i.e., collusion with corrupt officials). In the absence of enough public information, the level of private information and the expected net benefits from privately informed trading would be high (Diamond, 1985). Information asymmetry between potential buyers and sellers of equity creates trading frictions by introducing adverse selection, which impairs liquidity (Copeland and Galai, 1983; Glosten and Milgrom, 1985; Kyle, 1985).

Taken together, we hypothesize that corruption could hurt stock liquidity by lowering investor participation and destroying the information environment.

3.3 Data, variables, and sample description

3.3.1 Measuring stock liquidity

3.1 Measuring stock liquidity

We measure stock liquidity using both low-frequency and high-frequency measures. The first proxy of liquidity is the percentage effective bid-ask spread, which is a high-frequency measure. Bid-ask spread is a direct measure of liquidity. A high spread implies low liquidity. For stock i, the effective volume-weighted bid-ask spread in a given year is calculated as follows:

$$EBAS_i = \frac{1}{D_i}\sum_{d=1}^{D}\frac{1}{Volume_{i.d}}\left(\sum_{m=1}^{M}(2*\frac{|Price_{i,m}-(Ask_{i,m}+Bid_{i,m})/2|}{(Ask_{i,m}+Bid_{i,m})/2}*Volume_{i.m})\right)_{i,d}$$

where D_i is the number of trading days for stock i in the year; $Price_{i,m}$ is the price of stock i at transaction m; $Bid_{i,m}$ is the highest bid price for stock i at transaction m; $Ask_{i,m}$ is the lowest ask price for stock i at transaction m; $Volume_{i,m}$ is the trading volume for stock i at transaction m. M is the number of transactions for stock i in a day. The annual effective spread is the average daily effective spread over a year. We take the natural logarithm of effective volume weighted bid-ask spread (Espread)

The second measure is Amihud illiquidity, which is a low-frequency measure and captures the sensitivity of stock price to trading volume (Amihud, 2002). The idea for this measure is that, for a given amount of trading, illiquid stocks should experience a larger change in price. A higher Amihud illiquidity value corresponds to lower liquidity. Amihud's price impact ratio of stock i in a given year is defined as:

$$Amihud_i = 10^8 * \frac{1}{D_i} \sum_{d=1}^{D} \frac{|R_{i,d}|}{Vold_{i,d}}$$

Where $|R_{i,d}|$ is the absolute value of the daily return of stock *i* on day *d* considering reinvestment of cash dividends. $Vold_{i,d}$ is daily turnover of stock *i* on day *d*. We calculate the annual Amihud illiquidity as the natural logarithm of the average daily effective spread over a year (*Illiq*).

In the sensitivity analysis section, we further use two alternative measures of stock liquidity. Firstly, following Lesmond et al. (1999), we use the proportion of zero daily firm returns in a year (*Zeros*) as the liquidity measure. If the value of an information signal is insufficient to outweigh the costs associated with a transaction, then market participants may be unwilling to trade, leading to an observed zero return. Therefore, a higher value of *Zeros* represents higher illiquidity.

The second measure is quoted volume-weighted bid-ask spread is calculated as follows:

$$QBAS_i = \frac{1}{D_i} \sum_{d=1}^{D} \frac{1}{Volume_{i.d}} \left(\sum_{m=1}^{M} \left(\frac{Ask_{i,m} - Bid_{i,m}}{(Ask_{i,m} + Bid_{i,m})/2} * Volume_{i.m} \right) \right)_{i,d}$$

where D_i is the number of trading days for stock *i* in the year; $Price_{i,m}$ the price of stock *i* at transaction *m*; $Bid_{i,m}$ is the highest bid price for stock *i* at transaction *m*; $Ask_{i,m}$ is the lowest ask price for stock *i* at transaction *m*; $Volume_{i,m}$ is the trading volume for stock *i* at transaction *m*. M is the number of transactions for stock *i* in a day. We then annualize the quoted spread by calculating the average daily effective spread over a year. The annual quoted spread is the average daily quoted spread over a year. We take the natural logarithm of quoted volume weighted bid-ask spread (*Qspread*).

3.3.2 Measuring corruption

To measure the degree of corruption in a firm's environment, we use the annual number of corruption convictions of public officials in each province as our baseline measure of local corruption. We collect the number of corruption cases filed against public officials for each province in China for the period of 2009 to 2018 from annual procedural reports. We then construct a measure of local corruption as the number of total corruption cases filed per 10,000 population in a given province for a given year. Panel A of Table 1 shows the average annual corruption by province. The corruption and firm-level data are matched using each firm's register address. A higher conviction rate of public officials per capita corresponds to a more corrupt operating environment for the firm (Smith, 2016; Bu et al., 2022). The data show that Jilin, Xinjiang, Qinghai, and Ningxia are among the most corrupt provinces.

An important concern is that the provinces with few convictions could also be corrupt, the offenders are escaping detection or conviction. This lack of oversight could stem from the variance of the justice system across different provinces. However, given that direction, supervision, and assistance flow from central government, we expect moderate homogeneity of enforcement. This should help to alleviate the concern. To further mitigate the concern, we use a perception-based measure of corruption as a robustness check. To measure perceived corruption, we turn to survey data from the Chinese Social Survey (CSS) compiled by Chinese Academy of Social Sciences. The CSS includes questions asking respondents about their opinions on local corruption. Responses are coded on a 4-point scale, from (1) “least corrupt” to (4) “most corrupt.” We take the average of responses by province and year to come up with a province's overall corruption score. The survey is conducted every two years, and the missing years are averaged over the two years before and after.

3.3.3 Empirical model

To examine our hypothesis, we use the following regression model to relate measures of stock liquidity to political corruption:

$$Stock\ Liquidity_{i,j,t} = \beta_0 + \beta_1 Corruption_{j,t} + \beta_2 Controls_{i,j,t} + \delta_{\mathrm{i}} + \gamma_{\mathrm{t}} + \varepsilon_{i,t}$$

where *Stock Liquidity* is firm *i*’s stock liquidity in province *j* in year *t*. *Corruption* refers to the annual number of corruption convictions per 10,000 population in each province for a given year, and *Controls* is the set of control variables. We employ two proxies for stock liquidity, namely Amihud’s illiquidity measure (*Illiq*) and effective bid-ask spread (*ESpread*). *Controls* include the log of total assets (*Size*), leverage ratio (*Lev*), *Tobin's Q*, stock price (*Price*), Stock return volatility (*RetVol*), number of years since listing (*Age*), Annual stock return (*Return*), ownership dummy (*SOE*), the number of financial analysts following (*Analyst*), and log of GDP per capita in a province (*GDP*). We list all the above variable definitions in Appendix 3.A for ease of reference. δ represents firm, province, or industry fixed effects. γ represent year fixed effects.

3.3.4 Sample construction and summary statistics

Our original sample set includes all firms listed on Shenzhen or Shanghai Stock Exchange (A shares). Financial and market information of firms is collected from China Stock Market and Accounting Research Database (CSMAR). The GDP per capita of each province are collected from China City Statistical Yearbook. We exclude financial firms, special treatment (ST) firms, and firms with missing data from the sample. We end up with 21,777 firm-year observations from 2009 to 2018.

Panel B of Table 3.1 presents some descriptive statistics about the variables used herein. For each variable, we provide information about the mean and median values, the standard deviation, and the minimum and maximum and values at the 25th and 75th percentiles. On average, 0.235 public officials are convicted for corruption for every 10,000 people at the province level every year, and the Amihud illiquidity and percentage effective bid-ask. spread of an average firm in our sample are 0.056 and 0.186 respectively. In our analysis, we take the natural logarithm form of the dependent variable. In our sample, an average firm has size of 22.128, leverage ratio of 44%, stock return volatility of 0.029, log of listing years of 1.982, annual stock return of 0.314, financial analyst following of 7.555, stock price of 15.371 and Tobin' s Q of 2.117. SOE samples accounted for 41.5% and the average logarithm of per capital GDP is 10.292.

3.4 Empirical results

3.4.1 Baseline regression results

In this subsection, we provide the baseline OLS regression results. For each illiquidity measure (Illiq and Espread), we present three regression specifications with province, industry, and firm level fixed effect, respectively. We control for year fixed effects in all regression models.

We present the baseline regression results in Table 3.2. The estimated coefficient for the variable Corruption is positive and significantly related to all measures of stock market illiquidity. This finding implies that firms in less corrupt provinces have higher stock market liquidity than firms in more corrupt provinces. The magnitude of this effect is economically significant: for example, the increase in the level of corruption that reflects the difference between the fourth least corrupt province (Guangdong) and the fourth most corrupt province (Ningxia) is associated with a 1.59%[8] decrease in the firm's liquidity as measured by percentage effective bid-ask spread (3.19% as measured by Amihud illiquidity). The coefficients on most of the control variables are statistically significant, and their signs are broadly consistent with those reported in the existing literature (Foerster and Karolyi, 1999; Ng et al., 2016). The results indicate that stock liquidity tends to be lower for private firms, small firms, firms with low analyst coverage and low return variability, and poor performing firms.

3.4.2 Sensitivity analysis

In this subsection, we check whether the result we find is consistent across the alternative liquidity and corruption measures.

For stock liquidity, we use the proportion of zero daily firm returns in a year and Quoted volume-weighted bid-ask spread as alternative measures. As shown in Panel A of Table 3.3, our main results continue to hold with statistical and economic significance for the additional two alternative liquidity measures.

We also employ three different measures of corruption which encompass slight variations to the current measure and a perception-based measure. Firstly, as noted by Glaeser and

[8] According to Table 3.1, the difference in corruption (Average Annual Convictions per 10,000) between Ningxia and Guangdong is 0.404 - 0.193 = 0.211. Based on columns (5) and (6) of Table 3.2, the coefficients for Corruption are 0.0755 for percentage effective bid-ask spread and 0.151 for Amihud illiquidity, respectively. Thus, 0.0755 * 0.211 = 0.0159, which represents the increase in firm illiquidity as measured by percentage effective bid-ask spread due to the increase in corruption between Guangdong and Ningxia. Similarly, 0.151 * 0.211 = 0.0319 represents the increase in firm illiquidity as measured by Amihud illiquidity due to the increase in corruption between Guangdong and Ningxia.

Saks (2006), there may be a timing disconnect between when the convicted parties were engaging in corruption and when they were convicted, and we cannot identify the actual timing of the corrupt behavior. Accordingly, year-over-year fluctuations in the conviction rate are likely to include measurement errors. Thus, we smooth out the corruption proxy by measuring corruption using the 3-year trailing sum of convictions, scaled by the 3-year average population of the province (Corruption_3years). Secondly, to get a relative measure of province-level corruption, we scale each province's corruption rate by overall corruption rate in China for each year (Corruption_all). Thirdly, following Smith (2016), we use Corruption_top (i.e. per capital convictions multiplied by an indicator for the top quartile of political corruption) as the third alternative measure of political corruption. Lastly, we use the average score of precepted corruption for a given province each year (P_Corruption) as a corruption measure. We present the results in Panel B of Table 3.3. We find the coefficients of all four alternative measures of corruption are significantly positive.

3.4.2 Identification strategy

3.4.2.1 Propensity score matching (PSM)

Firms may have multiple motivations when choosing where to register. The choice of a firm's registration location could be endogenous. Firms registered in high corruption provinces and low corruption provinces may differ in many dimensions. Thus, we conduct a PSM analysis. We divide our sample into high- and low- corruption groups based on the median level of Corruption each year. We consider the subsample with high corruption as the treatment group, and the one with low corruption as the control group. For each of the observations in the treatment and control subsamples, we calculate the propensity score, i.e., the probability of belonging to the 'HI Corruption' group, using a logit model. We use all control variables in the main model and industry and year dummies as covariates. Then, for each observation from the treated subsample, we find the nearest neighbor with a 0.01 caliper. We match without replacement. To evaluate the validity of the matching procedure, we conduct the following matching diagnostic tests. We estimate a logit regression analysis predicting the probability of being in the treatment group. Panel A of Table 3.4 presents the results for the full sample in Column (1) and for the PSM subsample in Column (2). As shown in Column (2), the statistically insignificant coefficients of all control variables and the dramatic drop of the pseudo-R2 in the PSM subsample indicate that none of the control variables now predict which firms are more likely to be in the treatment group.

We report the results of after-matching samples in Panel B of Table 3.4. Only stock illiquidity measures (Espreas and Illiq) are significantly different between the two subsamples. None of the covariates show any significance.

3.4.2.2 Bartik-style Instrument Variable (IV)

Although we have used various controls commonly used in the literature and fixed effects to mitigate the endogeneity concerns, it could still be argued that our findings may be spurious. For instance, even though we control per capita GDP, it is possible that other local economic conditions may affect corruption as well as stock liquidity. To address the endogeneity concern, we employ the Bartik-style IV approach, which is particularly useful when studying local or regional economic outcomes. Our approach is employing an IV that changes the corruption level of a province but is unrelated to local economic conditions. Existing research has shown that significant historical shocks have influenced on current social norms (Nunn, 2008; Voigtländer and Voth, 2012). China's Great Leap Forward (GLF) movement in the late 1950s is such a well-known historical shock involving government misconduct. The Communist Party of China (CPC) launched the GLF movement, a radical economic and social campaign, to rapidly transform China from an agrarian economy into an industrialized society. During the three-year campaign period, local government officials aggressively boasted about grain yields to meet the unrealistically high targets. The CPC leadership applauded, rather than punished, local governments for their exaggerations. The People's Daily, the national news media, introduced the phrase “launching high-yield agricultural satellites” (fang gaochan weixing) to trumpet these fake achievements of record-breaking grain yields. As Chen et al. (2022) argued, the pattern of yield over-reporting behavior during the GLF period has persistent effects on contemporary local norms on honesty and integrity, thus serving as a good predictor of current local corruption. Following the concept of Bartik-style IV (Bartik, 1991), we interact the GLF over-reporting with a time-series variable that measures national corruption to capture the dynamics of corruption convictions. Specifically, in years when national corruption is severe, provinces with more GLF over-reporting would have more corruption convictions.

Replying on hand-collected data on GLF over-reporting, our construction of the instrument involves the following steps. First, we measure yield over-reporting at the province level using the number of "high-yield agricultural satellites" launched during the GLF period divided by the total population of each province in 1957. Following Kung and Chen (2011), we read through all the articles in People's Daily and count the number of launched "high-yield agricultural satellites" reports for each province between June 1958 and December 1960. Second, we calculate national level political corruption by adding up the number of corruption convictions by province each year from 2009 to 2018. Finally, we obtain the Bartik-type instrument for political corruption, which is the interaction between the province's historical wrongdoings reflected in yield over-reporting during the GLF and yearly national political corruption. More specifically, the instrument is constructed as:

$$IV_{jt} = GLF\ overreporting_{j0} * National\ Overall\ Corruption_t$$

The validity of the instrument lies in its relevance and exogeneity. First, when national political corruption is more severe, provinces with more past government wrongdoings tend to have more corruption convictions. Therefore, the Bartik instrument can strongly predict province-level political corruption. Second, we use the data of historical government misconduct which is unlikely to be correlated with current local economic conditions. Meanwhile, the national level political corruption is less likely to be correlated with the economic performance of different provinces; thus, this instrument is exogenous.

Column 1 of Table 3.5 presents the first stage estimation results. Consist with our prediction, IV is positively corrected with Corruption variable. The F-statistics reject the hypothesis of weak instruments, implying that the Bartik instruments can strongly predict the province-level political corruption. Column 2 and Column 3 report the second stage results. The coefficients of Corruption for both stock illiquidity measures remain positive and statistically significant, which support our main result.

3.4.2.3 Anti-corruption campaign as exogenous shock

China's anti-corruption campaign provides an ideal environment to study the causal impact of political corruption on corporate stock liquidity. After Xi Jinping came to power, he proposed to take the fight against corruption as a major political task. Especially, on October 19, 2013, the Organization Department of the Central Committee of the Communist Party of China (CCCPC) issued the "Opinions on Further Regulating the Appointments of Party and Government Leading Cadres in Enterprises" (referred to as Rule 18). Rule 18 stipulates that leading cadres who have been in office or retired (resigned) for less than three years are not allowed to serve in firms. Rule 18 is an important part of anti-corruption campaign and is highly authoritative. It triggered a massive wave of official director resignations in a short period of time (Hope et al., 2020).

Before Rule 18 was issued, it was common for current or former government officials to serve as independent directors in listed firms, which fostered corruption. Hiring government officials as directors is an effective way for firms to build close relationship with local government and political rent-seeking breeds from such close connection. In such cases, official directors act as bridge between firms and local government and firms rely more on bribery to gain various preferential treatment. In exchange, official directors get high salary or perquisites as payback. As a result, these firms may face more serious information asymmetry problems and lack the trust of investors.

The intensity and far-reaching impact of anti-corruption regulation is unanticipated. The release of Rule 18 is an exogenous shock to firms and official directors, which significantly weakened firms' exposure to political corruption. Rule 18 only focuses on firms with official independent directors (Hou et al., 2022). As such, it provides a unique experiment to cleanly identify affected group and to gauge the causal relationship between political corruption and firms' stock liquidity.

Taking advantage of the quasi-natural experiment of Rule 18, we use a difference-in-difference (DID) model to test how exogenous changes in a firm's likelihood of engaging in corruption affect its stock liquidity. The DID model is shown in Eq (2). In order to ensure that the treated firms and the control firms are comparable, we employ the matching method to construct our empirical sample. For each treatment firm, potential match firms are any firm without official directors prior to Rule 18, from the same province and the same industry. From the set of potential matches, we select the four with total asset closest to that of the treatment firm on 2013. The dummy variable *Treat* in Eq (2) is used to distinguish treated firms and control firms. Variable Treat equals to 1 for firms with official directors prior to the Rule 18, and 0 otherwise. The dummy variable *Post* captures the pre-post difference in stock liquidity around the release of Rule 18. *Post* equals to 1 for samples after 2013. Following Xu (2018), independent directors who have experience in serving as deputy cadres at the department or bureau level or above are defined as official directors [9].

$$Stock\ Liquidity_{ijt} = \alpha_0 + \alpha_1 Post_t + \alpha_2 Controls_t + Firm\ \ Fixed\ Effects\ + Year\ Fixed\ Effects + \varepsilon_{it} \qquad (2)$$

As shown in Table 3.6, the coefficients on the key variable of interest, Post, are negative and significant (-0.0138 with t-value=-2.055; -0.0427 with t-value=-2.494). Consistent with our proposition, the results suggest that compared with control firms, the stock liquidity for treatment firms with reduced corruption level due to Rule 18 experience an increase. Furthermore, the reliability of DID results is based on the parallel trend in the treatment and control groups firms to Rule 18. Result of parallel trend test are shown in column (2) and (4) and none of the interaction terms between *Treat* and year dummy variables before the events is significant. The results indicate that the parallel trend conditions required for causality are met. In addition, we exam the dynamic effect of Rule 18 by adding interaction terms Treat*POST1, Treat*POST2, Treat*POST3+. The result shows that in the second year following the event, the stock illiquidity of firms in the treatment group starts to decrease compared to the control firms. Figure 3.1 illustrates the dynamic effects of Rule 18 over the period from 2011 to 2016+. Overall, the results support the negative causal relationship between political corruption and stock liquidity.

[9] Official independent directors with experience working on the Chinese People's Political Consultative Conference and the People's Congress of the People's Republic of China are not taken into consideration, as holding positions in these two bodies does not carry governmental authority and is generally an honor. We do not consider independent directors with university work experience because such independent directors are not tied to any government power. At the same time, companies that only have independent directors with leadership experience below the department or bureau level are not considered disposal companies because anti-corruption regulations have no obvious impact on such independent directors (Xu, 2018; Hope et al., 2020).

3.4.3 Mechanism Analysis: Trading Activity and political corruption

We identify whether political corruption increase stock illiquidity through reducing trading activity utilizing a two-step regression approach. In the first step, we test the association between political corruption and trading activity. In the second step, we test the relationship trading activity and stock liquidity. If political corruption increases stock illiquidity by reducing trading activity, the coefficient of *Corruption* in the first step would be negative and the coefficient of variables representing trading activities would also be negative in the second step.

For intensity of stock trading activity, we use two proxies to measure: (1) number of shareholders (*Nshareholder*), defined as the natural logarithm of the total number of shareholders for each firm each year, (2) stock turnover (*Turn*), calculated as the average daily number of shares traded divided by the number of shares outstanding of each firm in each year and (3) the average number of trades per day (*NTrades*), defined as the natural logarithm of the average daily number of trades each year. The results are shown in Table 3.7. Panel A presents the first step regression results, which test whether there is any connection between stock trading activity and political corruption. The coefficients of *Corruption* on all trading activity measures, *Nshareholder*, *Turn* and *NTrades*, are significantly negative (-0.0687 with t-value=-1.878, -0.0764 with t-value = -2.942 and -0.0778 with t-value = -2.525), indicating that political corruption reduce trading activity. The results of the second step regression are shown in Panel B, which examines how these three variables affect stock liquidity. As shown from columns (4) to (9), the coefficients on *Nshareholder, Turn* and *NTrades* are significantly negative with both stock illiquidity measures (*Espread* and *Illiq*), suggesting a negative relation between trading activity and stock illiquidity.

Taken together, Table 3.7 demonstrates that the political corruption decreases investors' trading activity and reduced trading activity results in lower level of stock liquidity. Therefore, the above results support our assumption that political corruption destroys liquidity by decreasing investors' trading activity.

3.4.4 Mechanism Analysis: Asymmetric Information and political corruption

Like Section 4.3.1, to determine whether asymmetric Information is another mechanism through which political corruption impedes stock liquidity, we perform the following mechanism analysis using a two-step regression approach. In the first step, we examine the relation between political corruption and information asymmetry. In the second step, we examine the relation between information asymmetries and stock liquidity. If the political corruption reduces stock liquidity through exacerbating information asymmetry, we expect that political corruption is associated with higher information asymmetry in the first step regression while information asymmetries reduce stock liquidity in the second step regression.

We employ two variables to proxy the information environment of a firm, namely, Kim and Verrecchia's (2001) KV index (KV) [10], and Easley et al.'s (2012) Volume Synchronized Probability of Informed Trading (*VPIN*). We posit that higher levels of *KV* and *VPIN* and reflect greater information asymmetries (Reeb and Zhao, 2013; Dasgupta et al., 2010; Cheung et al., 2015). Table 3.8 presents our findings. We first regress each information environment measure on the political corruption, with all the control variable employed above included. The regression results of the first step model are shown in Panel A. The coefficients of *Corruption* are significantly positive (0.0301 with t-value=4.508, 0.00299 with t-value=1.977), suggesting that the political corruption destroy information

[10] Kim and Verrecchia (2001) suggest that stock returns are a function of stock trading volume. According to their view, when corporate information disclosures are less frequent and of lower quality, investors instead rely on the information contained in stock trading volumes. The KV indicator is obtained based on the coefficient of stock trading volume and is a reverse indicator of the quality of information disclosure. The larger the KV index, the higher the reliance of investors on the information contained in stock trading volume, indicating the lower quality of information disclosure. The advantage of the KV index is that it reflects investors' objective judgement of the degree of information asymmetry and can truly and comprehensively reflect the quality of information disclosure by listed firms, including both financial and non-financial information disclosure.
KV index is estimated using the following Model:

$$Ln\left|\frac{P_d - P_{d-1}}{P_{d-1}}\right| = \alpha + \beta(Volume_d - Volume_0) + \varepsilon_d$$

where P_d is stock price on day d, $Volume_d$ is the number of a firm's shares traded on day d, and $Volume_0$ is a firm's average trading volume of a year. Based on a sample of each company in each year, we run the regression to get the coefficient β. KV index for a firm in given year equals to the coefficient β multiplied by 100,000,000.

environment. The results of the second step regression are shown in Panel B. The coefficients on *KV* and *VPIN* are significantly positive for both stock liquidity measures (*Espread* and *Illiq*), indicating information asymmetry contribute to stock illiquidity. To summarize, these results confirm that political corruption can decrease liquidity through its influence on information asymmetry.

3.4.5 Cross-sectional tests: the impact of corruption tendency and external corporate governance

The impact of political corruption may be different for firms with different corruption tendencies. Thus, we further consider whether corruption tendency influence the relationship between corruption and stock liquidity.

SOEs have directly politically connection, as they are founded and owned by the government or the government agencies (Brandt and Li, 2003). However, in many important aspects, SOEs controlled by the central government (CSOEs) and LSOEs differ from each other. LSOEs are owned by provincial or municipal government, whose operations are mainly concentrated in one province so they are more strongly influenced by the local institutional environment. In addition, prior literature also proposes two different roles played by the government with regards to CSOEs and LSOEs, namely, “helping hand” and “grabbing hand” (Cheung, et al., 2010). In this sense, LSOEs are more likely to be involved in political corruption as measured in province level. Compared to SOEs, private firms without natural political connection, have more incentives get improper favors through bribery. This view is supported by existing research, for instance, Chen et al. (2013) suggest that private firms in China need to pay bribes to get more loans; Xu et al. (2017) show that for private firms, bribery is an effective way to help them get government procurement contracts and reduce government rent extraction. If so, the impact of political corruption should be strong for private firms. As shown in Panel A of Table 3.9, we divide our sample into three groups (CSOEs, LSOEs and Private firms) based on the ultimate ownership. The first group refers to CSOEs (columns (1) and (2)); the second group consists of provincial and municipal SOEs (columns (3) and (4)); and the third group consists of the private firms (columns (5) and (6)). In line with our expectation, the coefficients of *Corruption* are insignificantly for central SOEs group and significantly positive in LSOEs and private firms. The difference between the CSOEs and non-CSOEs groups is statistically significant. These results proves that the negative impact of political corruption exist in firms prone to corruption.

There are great differences in the degree of economic development and marketization of various provinces in China. Provinces with a higher degree of marketization have better information disclosure, stricter market supervision, and a fairer competitive environment (Hope et al. 2020). On the contrary, as the government intervenes more in the economy in provinces with low marketization, firms engage more in corruption to obtain resources and enhance competitiveness. (Liu, et al., 2016). From this perspective, stock liquidity for firms in high marketization regions tend to be less affected by political corruption. Following Li and Cheng (2020), we divide central or western provinces into less developed regions and eastern coastal provinces belong to more developed regions. Consistent with our predictions, the result of Panel B in Table 3.9 show only the coefficients of the *Corruption* in less developed provinces are significantly positive (0.0614 with t-value=2.687 and 0.134 with t-value=3.473) which means firms in regions with a low degree of marketization are more affected by the political corruption, but the difference between the high and low groups is not statistically significant.

Financial analyst is viewed as an important information intermediary in the financial market, playing the monitoring role of an external advisor (Chen et al., 2016). Financial analysts engage in information acquisition and provide valuable information about the business to investors. They improve the information environment through their analyses, forecasts, and recommendations (Chan and Hameed, 2006). Thus, we employ financial analysts as a proxy for external governance advisors and expect that strong external governance effectively moderates the adverse effect of political corruption on stock liquidity. Based on the median analyst following for each year, firms are separated into high analyst following and analyst following groups. Some evidence in Panel C in Table 3.9 shows that the relation is stronger for firms with Less analysts following but only for Amihud illiquidity measure.

3.5 Further analyses

The optimal capital structure is affected by the net cost of equity and the net cost of debt (Modigliani and Miller, 1958, Modigliani and Miller, 1963). Factors that would increase the net cost of equity, such as decreased liquidity, would therefore makes firms more dependent on debt financing (Lipson and Mortal, 2009). We explore whether lower stock liquidity induced by political corruption, which reduces the relative advantage of equity financing, leads to relatively higher usage of debt. One step further about debt maturity structure, from the perspective of supply-side, given that monitoring costs and risks are higher for long-term debt than for short-term debt, lenders are less likely to provide long-term debt in high corruption environments. As borrowers, firms operating in corrupt areas face more business uncertainty, cash flow fluctuations, and information opacity. Some studies have found that when external frictions are high, suppliers will tend to provide shorter-term loans rather than long-term loans in order to remain cautious and reduce losses (Rajan and Zingales, 1995; Custódio et al., 2013; Waisman et al., 2015). Thus, we predict that lenders will prefer to issue shorter-term debt. We expect the increase in debt financing resulting from the reduction in corruption-induced liquidity to be primarily short-term rather than long-term.

The results are shown in Table 3.10. The dependent variable of column (1) is long term debt measured by long-term debt divided by total assets and the dependent variable of column (2) is short term debt measured by short-term debt divided by total assets. Total sample is divided into two groups according to the median of bis-ask spread in each year. We define *Illiquid* as a dummy variable that takes a value of 1 if the firm falls into the low stock liquidity group, and is otherwise 0. For long-term debt, the coefficient of interaction term *Corruption* Illiquid* is significantly negative (-0.0185 with t-value=-2.721), indicating that the debt providers reducing long-term debt to avoid risk. For short-term debt, the coefficient of interaction term Corruption* Illiquid is significantly positive (0.0285 with t-value= 2.610), suggesting that because of the equity constraints caused by corruption, firms turn to increased short-term debt financing.

3.6 Conclusion

This paper examines how political corruption impacts liquidity in financial markets. We show that firms located in more corrupt provinces in China have lower stock market liquidity. We use various methods to address endogeneity issue, including control for broad set of firm and province characteristics and includes firm and year fixed effect, use propensity score matching method, adopt Bartik-style instrument variable, and perform DID analysis based on anti-corruption regulation. All the results support the main finding. The results do not change when we use alternative corruption and liquidity measures and alternative sample.

We find evidence that political corruption has an impact on stock liquidity through their influence on investors' trading activities and firms' information environment. Specifically, the impact of local political corruption on stock liquidity is more pronounced for LSOEs, private firms and firms in less developed regions which are more corruption-prone.

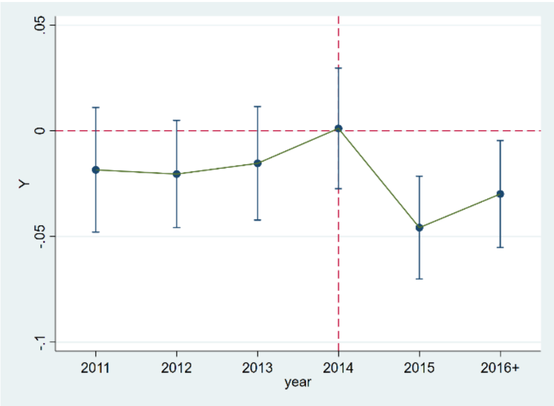
Overall, this research adds to the literature by showing that in emerging countries like China, corruption is an important institutional determinant of stock liquidity. Since quality of financial markets matters in the development of economic output, this paper contributes to a better understanding of the role political corruption plays in the real economy.

Tables of Figure

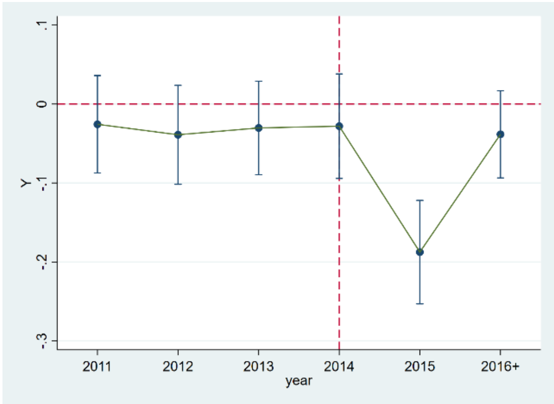
Figure 3.1 Dynamic effect of Rule 18

This figure illustrates the dynamic effects of Rule 18 over the period from 2011 to 2016+. The y-axis represents the stock illiquidity level. The x-axis spans the years from 2011 to 2016 and beyond. Each point on the graph represents the estimated effect for a specific year, with the vertical lines indicating the 95% confidence intervals around these estimates.

Espread:



Illiq:



Tables of Results

Table 3.1 Sample Overview

This table reports summary statistics for all the datasets, including the political corruption data, firm level data extracted form CSMAR database, and province level data extracted from China Statistical Yearbook. Panel A shows Political Corruption by province. Political corruption is measured as the number of total corruption cases filed per 10,000 citizens in a given province and a given year over the period of 2009 to 2018. Column (1) (3) and (5) shows the province name, Column (2) (4) and (6) show average annual convictions per 10,000. Panel B shows the summary statistics of main variables. Information is provided for means, standard deviation, minimum value, p25 value, median, p75 value and maximum value over the period 2009 to 2018. Panel C presents the Pearson correlation results. Definitions of all variables are provided in the Appendix 3. A.

Panel A Political Corruption by Province

Province	Avg. Annual Convictions per 10,000	Province	Avg. Annual Convictions per 10,000	Province	Avg. Annual Convictions per 10,000
Chongqing	0.240	Fujian	0.267	Yunnan	0.335
Shanghai	0.149	Hainan	0.261	Heilongjiang	0.345
Beijing	0.175	Guizhou	0.271	Liaoning	0.353
Tianjin	0.230	Guangxi	0.275	Ningxia	0.404
Tibet	0.175	Gansu	0.298	Xinjiang	0.422
Guangdong	0.193	Henan	0.309	Anhui	0.232
Jiangsu	0.197	Shanxi (陕西）	0.311	Jiangxi	0.248
Zhejiang	0.207	Inner Mongolia	0.310	Hebei	0.259
Hunan	0.208	Shanxi (山西）	0.334	Shandong	0.258
Sichuan	0.207	Hubei	0.331	Qinghai	0.436
				Jilin	0.481

Panel B Descriptive statistics

Variables	Mean	S. D.	Min	P25	P50	P75	Max
BAS	0.186	0.060	0.066	0.144	0.177	0.218	0.439
Amihud	0.056	0.066	0.002	0.019	0.037	0.070	0.969
Corruption	0.235	0.100	0.038	0.183	0.219	0.270	1.626
Lev	0.440	0.210	0.035	0.272	0.436	0.601	0.929
RetVol	0.029	0.009	0.010	0.023	0.028	0.033	0.066
Age	1.982	0.923	0.000	1.386	2.197	2.773	3.258
Earning	0.314	0.534	-2.575	0.057	0.233	0.500	3.296
Size	22.128	1.273	19.350	21.210	21.958	22.862	26.250
SOE	0.415	0.493	0	0	0	1	1
Analyst	7.555	9.297	0	1	4	11	46
Price	15.371	11.363	2.450	7.739	12.019	19.096	84.586
Tobin's Q	2.117	1.482	0.811	1.268	1.663	2.401	17.729
GDP	10.292	0.752	7.208	9.842	10.311	10.898	11.485

Panel C Pearson correlation													
Variables	BAS	Amihud	Corruption	Lev	RetVol	Age	Earning	Size	SOE	Analyst	Price	Tobin's Q	GDP
BAS	1												
Amihud	0.412***	1											
Corruption	0.056***	0.013*	1										
Lev	0.160***	-0.098***	0.081***	1									
RetVol	-0.117***	0.092***	0.025***	-0.043***	1								
Age	0.100***	-0.193***	0.092***	0.380***	-0.107***	1							
Earning	-0.350***	-0.144***	-0.056***	-0.130***	-0.153***	-0.095***	1						
Size	-0.091***	-0.359***	0.004	0.487***	-0.237***	0.352***	0.238***	1					
SOE	0.042***	-0.122***	0.073***	0.297***	-0.116***	0.427***	-0.001	0.337***	1				
Analyst	-0.326***	-0.245***	-0.059***	-0.019***	-0.124***	-0.078***	0.479***	0.359***	0.003	1			
Price	-0.446***	-0.046***	-0.060***	-0.274***	0.268***	-0.395***	0.433***	-0.163***	-0.198***	0.326***	1		
Tobin's Q	-0.133***	0.003	0.005	-0.233***	0.364***	0.024***	-0.036***	-0.430***	-0.134***	0.012*	0.334***	1	
GDP	-0.056***	0.021***	-0.304***	-0.115***	-0.009	-0.149***	0.069***	-0.01	-0.256***	0.039***	0.095***	-0.025***	1

Table 3.2 Political corruption and Stock illiquidity: Baseline results.

This table presents regression results of stock liquidity on political corruption and control variables. In column (1) and (2), province fixed effects and year fixed effects are included. In column (3) and (4), industry fixed effects and year fixed effects are included. In column (5) and (6), firm fixed effects and year fixed effects are included. In column (7) and (8), firm fixed effects and year- industry fixed effects are included. The dependent variable of column (1) (3) and (5) is the natural logarithm of the average of the daily volume weighted average of effective spreads in a given year. The dependent variable of column (2) (4) and (6) is the natural logarithm of the annual Amihud ratio, measured over a firm's fiscal year. Definitions of control variables are provided in the Appendix (Annex 3. A). Standard errors are clustered at the province-year level and t-values are depicted in parentheses with ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

	Espread	Illiq	Espread	Illiq	Espread	Illiq	Espread	Illiq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Corruption	0.0543**	0.114***	0.0669**	0.0973*	0.0755***	0.151***	0.0354*	0.120***
	(2.348)	(2.726)	(2.064)	(1.713)	(3.203)	(3.365)	(1.872)	(2.989)
Lev	0.198***	0.744***	0.150***	0.611***	0.118***	0.433***	0.108***	0.422***
	(18.98)	(25.83)	(13.98)	(20.40)	(7.687)	(9.510)	(7.229)	(9.175)
RetVol	-7.078***	-11.34***	-7.148***	-10.16***	-5.632***	-7.350***	-5.239***	-3.984
	(-8.661)	(-3.434)	(-8.842)	(-3.138)	(-9.304)	(-2.857)	(-8.886)	(-1.456)
Age	-0.0126***	-0.120***	-0.0117**	-0.120***	0.00341	-0.231***	0.0220***	-0.186***
	(-2.864)	(-12.01)	(-2.476)	(-12.22)	(0.367)	(-11.70)	(2.663)	(-9.295)
Return	-0.0846***	0.0271**	-0.0981***	-0.0200	-0.0840***	-0.0676***	-0.0810***	-0.0493***
	(-15.85)	(1.979)	(-18.69)	(-1.477)	(-14.80)	(-4.630)	(-14.14)	(-3.488)
Size	-0.0390***	-0.478***	-0.0465***	-0.480***	-0.0739***	-0.364***	-0.0669***	-0.361***
	(-9.960)	(-48.90)	(-11.50)	(-48.53)	(-12.92)	(-19.21)	(-11.80)	(-19.10)
SOE	-0.0223***	0.0115	-0.0281***	-0.00392	0.0167	-0.0660*	0.00347	-0.0919**
	(-5.216)	(0.907)	(-6.318)	(-0.301)	(1.288)	(-1.926)	(0.262)	(-2.543)
Analyst	-0.00542***	-0.0188***	-0.00473***	-0.0176***	-0.00604***	-0.0179***	-0.00546***	-0.0171***
	(-16.91)	(-24.12)	(-14.85)	(-21.88)	(-15.13)	(-17.34)	(-12.98)	(-16.08)
Price	-0.00823***	-0.00544***	-0.00686***	-0.00252***	-0.00313***	-0.00347***	-0.00233***	-0.00266**
	(-12.80)	(-6.303)	(-10.83)	(-2.970)	(-4.264)	(-2.723)	(-3.627)	(-2.333)
Tobin's Q	0.00140	-0.113***	0.00259	-0.106***	0.00576**	-0.0368***	0.00323	-0.0441***
	(0.699)	(-12.21)	(1.418)	(-12.15)	(2.475)	(-4.468)	(1.517)	(-5.769)
GDP	-0.158***	-0.154**	0.00710*	0.0362***	-0.161***	-0.132*	-0.109***	-0.0736
	(-5.155)	(-2.114)	(1.661)	(4.012)	(-4.685)	(-1.823)	(-3.622)	(-1.120)

Constant	1.042***	9.329***	-0.456***	7.113***	1.726***	6.668***	1.002***	5.530***
	(3.336)	(12.17)	(-3.974)	(21.94)	(4.812)	(7.620)	(3.074)	(6.471)
Obs.	21,777	21,777	21,777	21,777	21,777	21,777	21,777	21,777
Year F.E.	YES	YES	YES	YES	YES	YES	NO	NO
Pro. F.E.	YES	YES	NO	NO	NO	NO	NO	NO
Ind. F.E.	NO	NO	YES	YES	NO	NO	NO	NO
Ind- Year F.E.	NO	NO	NO	NO	NO	NO	YES	YES
Firm F.E.	NO	NO	NO	NO	YES	YES	YES	YES
R-squared	0.427	0.608	0.471	0.63	0.414	0.549	0.499	0.598

Table 3.3 Sensitivity analysis: alternative measures of stock liquidity and political corruption

This table presents regression results of stock liquidity on political corruption and control variables using alternative measures of stock liquidity and political corruption. Panel A presents regression results of stock liquidity on political corruption and control variables using alternative measures of stock and Panel B presents regression results using alternative measures of political corruption and Panel C presents regression results using samples excluding firms in Shanghai, Beijing, Chongqing, and Tianjin. In panel A, the dependent variable Zeros is the proportion of zero daily firm returns in a year and the dependent variable Qspread is the natural logarithm of the average of the daily volume weighted average of quoted spreads in a given year. In panel B, the main independent variable of column (1) and (2) is *Corruption_ 3 years*, measured as the 3-year trailing sum of convictions, scaled by the 3-year average population of the province. The main independent variable of column (3) and (4) is Corruption _ all, measured as the conviction rate for each province scaled by total conviction rate of China each year. The main independent variable of column (5) and (6) is Corruption_ top, measured as Per 10,000 capita convictions multiplied by an indicator for the top quartile of corruption in each year. The main independent variable of column (7) and (8) is P _ Corruption, measured as the average score of households' response of a Chinese Social Survey (CSS) survey question asking about opinions on local corruption of each province in each year. In panel C, we re-estimate the main result using the subsample excluding firms in Shanghai, Beijing, Chongqing, and Tianjin. All control variables in main regression, firm and year fixed effect are included in all regressions. Definitions of control variables are provided in the Appendix (Annex 3. A). Standard errors are clustered at the province-year level and t-values are depicted in parentheses with ***, **, * indicating statistical significance at 1%, 5% and 10% respectively.

Panel A: Alternative measures of stock liquidity

	Zeros	Qspread
	(1)	(2)
Corruption	0.0796***	0.101**
	(3.301)	(2.398)
Obs.	21,777	20,686
Controls	YES	YES
Firm F. E.	YES	YES
Year F. E.	YES	YES
R-squared	0.447	0.407

Panel B: Alternative measures of political corruption

	Corruption_ 3years		Corruption _ all		Corruption _ top		P _ Corruption	
	Espread	Illiq	Espread	Illiq	Espread	Illiq	Espread	Illiq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Alter. Corruption	0.0785***	0.0832**	0.0213***	0.0388***	0.0439***	0.0946***	0.0755***	0.120*
	(5.389)	(2.005)	(3.191)	(3.032)	(2.690)	(3.214)	(2.861)	(1.835)
Obs.	21,777	21,777	21,777	21,777	21,777	21,777	19,720	19,720
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.415	0.549	0.414	0.549	0.415	0.549	0.413	0.551

Panel C: Excluding firms in Shanghai, Beijing, Chongqing, and Tianjin

	Espread	Illiq
	(1)	(2)
Corruption	0.0463**	0.110***
	(2.11)	(2.89)
Obs.	17,538	17,538
Controls	YES	YES
Firm F. E.	YES	YES
Year F. E.	YES	YES
R-squared	0.410	0.542

Table 3.4 Propensity scores matching analysis.

This table reports results of Propensity Score Matching. We divide our sample into two subsamples based on the median level of Political Corruption each year. Panel A of Table 3.4 presents the results for the full sample in Column (1) and for the PSM subsample in Column (2). In Panel B, Column (1) and (2) represents the mean value and standard deviation of high corruption group sample. Column (3) and (4) represents the mean value and standard deviation of low corruption group sample. In the last two columns we present the mean differences between the treatment and control groups, as well as the t-stat for differences. *, **, and *** refer to 10%, 5%, and 1% levels of significance, respectively.

Panel A: PSM diagnostic Logit regression

Sample	Full sample (pre-matched)	PSM subsample (post-matched)
Variables	Treated group	
Lev	1.150***	0.0684
	(7.938)	(0.425)
RetVol	-8.618*	2.305
	(-1.940)	(0.461)
Age	0.132***	-0.000922
	(3.487)	(-0.0220)
Earning	0.0823*	-0.0232
	(1.715)	(-0.462)
Size	-0.197***	-0.0170
	(-5.445)	(-0.422)
SOE	-0.217**	-0.0111
	(-2.441)	(-0.124)
Analyst	0.00171	0.00109
	(0.521)	(0.328)
Price	-0.000823	-0.000672
	(-0.296)	(-0.237)
Tobin's Q	-0.0690***	-0.00895
	(-3.782)	(-0.442)
GDP	-1.206***	0.0570
	(-4.271)	(0.197)
Obs.	21,761	14,223
Ind. F. E.	Yes	Yes
Year F. E.	Yes	Yes
Pseudo R2	0.1417	0.0027

Panel B: Propensity scores matching results

	HI Corruption		LO Corruption		Difference (HI – LO)
Variables	MEAN	S.D.	MEAN	S.D.	t-stat for difference
Espread	-1.725	0.325	-1.746	0.317	4.05***
Illiq	-3.304	0.945	-3.356	0.973	3.27***
Lev	0.441	0.21	0.439	0.205	0.70
RetVol	0.0289	0.00889	0.0287	0.00907	1.27
Age	1.993	0.911	2.00195	0.913	-0.58
Earning	0.32	0.54	0.332	0.522	-1.26
Size	22.122	1.234	22.143	1.311	-1.39
SOE	0.414	0.493	0.419	0.493	-0.54
Analyst	7.514	9.299	7.621	9.195	-0.69
Price	15.17	11.361	15.376	11.0261	-1.1
Tobin's Q	2.105	1.593	2.118	1.312	-0.53
GDP	10.291	0.625	10.29	0.618	0.17

Table 3.5 Instrumental Variable Regression

This table presents the effect of political corruption on stock liquidity using two-stage least squares regressions. We use a Bartik-type instruments for the corruption firms face in its operating environment: an interactive term that that combines yearly variation in the national level political corruption with cross-sectional variation in a province's historic misconduct. Column 1 shows the first stage of the regression, and columns 2 and 3 show the second stage for Espread and Illiq, respectively. The regressions use all controls from Table 2, but we do not report the coefficients for brevity. Diagnostic tests on endogeneity are reported. All control variables in main regression, firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	First Stage	Second Stage	
	Corruption	Espread	Illiq
	(1)	(2)	(3)
IV	0.000725***		
	(3.23)		
Corruption		0.407**	1.489***
		(2.165)	(2.779)
Weak identification F -test	10.419		
K–P underid. P	0.056		
Obs.	21,325	21,325	21,325
Controls	YES	YES	YES
Firm F. E.	YES	YES	YES
Year F. E.	YES	YES	YES
R-squared	0.086	0.162	0.137

Table 3.6 Effect of Anti-corruption regulation on stock liquidity.

This table reports the effect of anti-corruption regulation on stock liquidity. Treat is design to equal to 1 if the firm has at least one official director before the launch of Rule 18, and 0 for matched control firms. Post is taken 1 for observations since 2014. PRE3, PRE2 and PRE1 equal one for the firm-year observation of the treatment group 3, 2 and 1 year before the release of Rule 18, and zero otherwise. POST0, POST1 and POST2+ equal one for the firm-year observation of the treatment group 0, 1 and 2+ year after the release of Rule 18, and zero otherwise. The regressions use all controls from Table 3.2, but we do not report the coefficients for brevity. Firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province-year level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Espread		Illiq	
	(1)	(2)	(3)	(4)
Treat * PRE3		-0.0185		-0.0259
		(-1.233)		(-0.826)
Treat * PRE2		-0.0205		-0.0393
		(-1.593)		(-1.232)
Treat * PRE1		-0.0155		-0.0308
		(-1.134)		(-1.023)
Treat * POST1		0.00114		-0.028
		-0.0788		(-0.835)
Treat * POST2		-0.0458***		-0.188***
		(-3.712)		(-5.635)

Treat * POST3+		-0.0299**		-0.0384
		(-2.328)		(-1.367)
Treat * Post	-0.0138**	-0.0267**	-0.0427**	-0.0658***
	(-2.055)	(-2.233)	(-2.494)	(-2.641)
Obs.	13,080	13,080	13,080	13,080
Controls	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES
R-squared	0.416	0.416	0.56	0.56

Table 3.7 Mechanism Analysis: trading activity

This Table reports the effect of political corruption on stock liquidity through constraining trading activities. Panel A is the result of regression of trading activity on political corruption, and Panel B is the result of regression of stock illiquidity on trading activity. Trading activity is measured by *Nshareholder* which equals to the natural logarithm of the total number of shareholders in a given year, *Turn* which equals to the natural logarithm of the total number of shares traded each year, scaled by the number of shares outstanding and *Ntrades* which equals to the natural logarithm of average of daily number of trades each year. The regressions use all controls from Table 2, but we do not report the coefficients for brevity. Firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province-year level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Panel A: regression of Trading Activity on Political corruption			Panel B: regression of Stock illiquidity on Trading Activity					
	Nshareh	Turn	Ntrades	Espread	Illiq	Espread	Illiq	Espread	Illiq
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Corruption	-0.0687*	-0.0764***	-0.0778**						
	(-1.878)	(-2.942)	(-2.525)						
Nshareholder				-0.150***	-0.449***				
				(-28.26)	(-31.03)				
Turn						-0.237***	-0.886***		
						(-41.29)	(-56.53)		
Ntrades								-0.159***	-0.851***
								(-24.39)	(-71.20)
Obs.	20,923	21,777	21,777	20,923	20,923	21,777	21,777	21,777	21,777
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.385	0.709	0.73	0.466	0.6	0.52	0.707	0.478	0.745

Table 3.8 Mechanism Analysis: asymmetric information.

This table reports the effect of political corruption on stock liquidity through increasing information asymmetry. Panel A is the result of regression of information asymmetry on political corruption, and Panel B is the result of regression of stock illiquidity on information asymmetry. Information asymmetry is measured by KV index following Kim and Verrecchia (2001) and Probability of informed trading computed following the microstructure model by Easleyet al. (2012). The regressions use all controls from Table 2, but we do not report the coefficients for brevity. Firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province-year level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Panel A: regression of Information Asymmetry on Political corruption	Panel B: regression of Stock illiquidity on Information Asymmetry

	KV	VPIN	Espread	Illiq	Espread	Illiq
	(1)	(2)	(3)	(4)	(5)	(6)
Corruption	0.0301***	0.00299**				
	(4.508)	(1.977)				
KV			0.444***	1.032***		
			(17.01)	(19.08)		
VPIN					4.895***	13.49***
					(22.89)	(20.69)
Obs.	21,727	21,179	21,727	21,727	21,179	21,179
Controls	YES	YES	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES	YES	YES
R-squared	0.293	0.593	0.448	0.583	0.461	0.591

Table 3.9 Cross-sectional tests

This table presents the effect of political corruption on stock liquidity considering the firms' corruption tendency and external corporate governance. Panel A presents the results considering whether the firm; s ownership. Panel B shows the results considering whether the firm is from more developed provinces or less developed provinces. Column (1) and (2) of Panel A consist of sample of firms controlled by central government. Column (2) and (3) of Panel A consist of sample of firms controlled by provincial or municipal government. Column (5) and (6) of Panel A consist of sample of private firms. Column (1) and (2) of Panel B consist of sample of firms registered in more developed provinces. Column (3) and (4) of Panel B consist of sample of firms registered in less developed provinces. Column (1) and (2) of Panel C consist of sample of firms with more analysts following. Column (3) and (4) of Panel C consist of sample of firms with more analysts following. The regressions use all controls from Table 3.2, but we do not report the coefficients for brevity. Firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province-year level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: CSOEs versus LSOEs versus private firms

	Espread			Illiq		
	Central SOE	Provincial/ Municipal SOE	Private firms	Central SOE	Provincial/M unicipal SOE	Private firms
	(1)	(2)	(3)	(4)	(5)	(6)
Corruption	0.00259	0.0615**	0.0931***	-0.0477	0.123**	0.217***
	(0.0983)	(2.182)	(3.003)	(-0.546)	(2.088)	(3.728)
Obs.	6,672	7,004	6,822	6,977	7,291	7,143
Controls	YES	YES	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES	YES	YES
R-squared	0.496	0.479	0.405	0.594	0.57	0.563
Diff. (P-Value)	0.078*			0.099*		

Panel B: firms in more developed provinces versus firms in less developed provinces

	Espread				Illiq	
	More developed provinces	Less developed provinces			More developed provinces	Less developed provinces

	(1)	(2)	(3)	(4)
Corruption	0.0340	0.0614***	0.0848	0.134***
	(0.307)	-2.687	(0.280)	-3.473
Obs.	12,085	9,692	12,085	9,692
Controls	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES
R-squared	0.440	0.396	0.563	0.536
Diff. (P-Value)	0.95		0.89	

Panel C: firms with more analysts following versus firms with less analysts following				
	Espread		Illiq	
	More analysts following	Less analysts following	More analysts following	Less analysts following
	(1)	(2)	(3)	(4)
Corruption	0.0880***	0.0511**	0.0751	0.200***
	(2.630)	(2.288)	(1.137)	(3.972)
Obs.	10,536	11,241	10,536	11,241
Controls	YES	YES	YES	YES
Firm F. E.	YES	YES	YES	YES
Year F. E.	YES	YES	YES	YES
R-squared	0.382	0.461	0.572	0.514
Diff. (P-Value)	0.28		0.058*	

Table 3.10 Further analyses

This table presents the effect of political corruption on debt financing conditional on firms' stock liquidity level. The dependent variable of column (1) and (2) is Long-term debt measured by long-term debt divided by total assets. The dependent variable of column (3) and (4) is short-term debt measured by short-term debt divided by total assets. The regressions use all controls from Table 2, but we do not report the coefficients for brevity. Firm and year fixed effect are included in all regressions. The t-statistics based on robust standard errors clustered at the province-year level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Long-term debt	Short-term debt
	(1)	(2)
Corruption	0.00140	-0.00348
	(0.249)	(-0.346)
Illiquid	0.00483***	-0.0102***
	(2.851)	(-3.606)
Corruption* Illiquid	-0.0185***	0.0285***
	(-2.721)	(2.610)
Lev	0.0759***	0.524***
	(16.55)	(34.33)
RetVol	0.0172	0.00591
	(0.230)	(0.0387)
Age	0.00853***	0.00748***
	(5.976)	(2.781)
Return	0.000207	-0.0197***
	(0.196)	(-9.264)
Size	0.0118***	0.00926***

	(9.673)	(3.601)
SOE	0.00169	-0.00150
	(0.515)	(-0.210)
Analyst	0.0000282	-0.000261**
	(0.0485)	(-2.528)
Price	0.000238***	-0.000200*
	(4.513)	(-1.717)
Tobin's Q	-0.00117***	0.00136
	(-2.866)	(1.162)
GDP	-0.0154*	0.0147
	(-1.714)	(1.259)
Constant	-0.0854	-0.188
	(-0.969)	(-1.600)
Obs.	21,753	21,753
Firm F. E.	YES	YES
Year F. E.	YES	YES
R-squared	0.066	0.338

Appendix to Chapter 3

Appendix 3. A Variables Definitions

Variables	Definition
Espread	The natural logarithm of the average of the daily volume weighted average of effective spreads in a given year.
Illiq	The natural logarithm of the annual Amihud ratio, measured over a firm's fiscal year.
Qspread	The natural logarithm of the average of the daily volume weighted average of quoted spreads in a given year.
Zeros	The proportion of the number of days with zero stock returns to the total number of days with non-missing stock returns in a given year.
Corruption	The number of corruption convictions per 10,000 population of the province.
Corruption_ 3years	The 3-year trailing sum of convictions, scaled by the 3-year average population of the province.
Corruption _ all	This is a modified version of our main Corruption measure. The conviction rate for each province scaled by total conviction rate of China each year.
Corruption _ top	Per 10,000 capita convictions multiplied by an indicator for the top quartile of corruption in each year.
P _ Corruption	The average score of households' response of a Chinese Social Survey (CSS) survey question asking about opinions on local corruption of each province in each year. Responses are coded on a 4-point scale, from (1) "least corrupt" to (4) "most corrupt".
Size	Natural logarithm of total assets.
Lev	Total liability scaled by total assets.
Tobin's Q	The ratio of the sum of market value of tradable shares, book value of non-tradable shares and liabilities to book value of total assets.
Price	The average daily closing price of the stock in the year.
RetVol	Standard deviation of daily stock returns.
Age	The natural logarithm of the number of years since the firm went public.
Return	Annual stock return in the previous year.

SOE	A dummy variable representing the nature of equity, which equals 1 for SOEs, 0 otherwise,
Analyst	The number analysts following in a given year.
GDP	The natural logarithm of per capita GDP of provinces where the firm is registerd.
Nshareholder	The natural logarithm of the total number of shareholders in a given year.
Ntrades	The natural logarithm of average of daily number of trades each year.
Turn	The natural logarithm of the total number of shares traded each year, scaled by the number of shares outstanding.
VPIN	Probability of informed trading computed following the microstructure model by Easleyet al. (2012).
KV	KV index following Kim and Verrecchia (2001).

Concluding Remarks

Over the past three decades, China have attracted considerable media and academic attention in their transition. This attention can partly be explained by the rapid economic growth and the unique features of Chinese government. In China, as the one-party political system and the centrally planned economy render bureaucrats with great monopolistic powers, the government exerts considerable influence over the market. In practice, Chinese government is extensively involved in economic. Inevitably, firm decision and performance are closely related to political pressure, public policies, and public governance.

As China is rapidly becoming one of the largest economies in the world and a leading destination for investment, pollution issues are becoming more prominent. In response to severe environmental pollution and resource waste, the Chinese government has imposed political pressure on firms and promulgated several environmental policies, such as the pollution penalty, emission trading, permit system, green credit policy and environmental subsidies. Overall, political pressure and environmental regulations set by governments are regarded as the main factors influencing firms' environmental decisions and actions (Nesta et al., 2014). In addition to exerting influence on firms in terms of environmental protection, government directly shapes the firms' operating environment and its behaviors affect firms' secondary market liquidity. Accordingly, this thesis examines the following research questions: i) Following regional pollution emergencies, the impact of the negative judgement of stakeholders such as government on the CSR strategy of local firms; ii) How environmental policy mix of green credit policy and government subsidies influences the high-quality environmental innovation of highly polluting firms; iii) Whether political corruption in China impedes stock liquidity.

Overall, the first chapter investigates the motivation behind CSR strategy following regional pollution emergencies and examines whether the CSR strategy is effective. This chapter proposes that CSR can be used to build trust among stakeholders represented by government when they have negative sentiments about environmental issues. Trust is a kind of subjective perception, which cannot be easily measured. Using DID method and taking advantage of the unexpected shock of extreme regional pollution emergencies that lead to sudden increases in stakeholder environmental concerns, we could identify the trust-building motivation behind the CSR strategy. Results suggest that local firms indeed strategically improve CSR to build trust following pollution emergencies, and this is specifically true for highly-polluting firms. Further results suggest that firms that gain trust through CSR activities after pollution emergencies are rewarded. CSR serves as a buffer against financial constraints, financing distress and negative profitability effect following emergencies. Therefore, the main implication of the chapter is that political pressure may be a key mechanism driving firms to improve CSR, other channel includes institutional shareholders and public monitoring.

The second chapter examines to what extent the policy mix of green credit policy and government subsidy affects the high-quality environmental innovation of high-polluting firms. The key finding of the chapter is that green credit policy negatively impacts the high-quality environmental innovation of high-polluting firms in China. Next, this chapter examines the interaction effect of green credit policy and government subsidies on high-quality environmental innovation and finds that the policy mix of green credit policy and government subsidies is positively related to high-quality environmental innovation. The effect of the policy mix is more pronounced for SOEs, firms with political connections, firms in areas with low marketisation, and large firms. Additionally, this chapter explores why green credit policy hinder high-quality environmental innovation. Results show that there was an increase in compliance costs for high-polluting firms after the implementation of green credit policy and that high compliance costs crowd out high-quality environmental innovation. Results also show that bank credit does not flow to high-polluting firms with high-quality environmental innovation, which creates credit allocation inefficiency after green credit policy. However, government subsidies can act as a certification for firms with a high level of high-quality environmental innovation and help alleviate credit allocation inefficiency. These findings imply that different policy instruments could interact with each other and motivate firms to undertake high-quality environmental innovation which give implications for global environmental policy makers.

The final chapter exams whether political corruption impedes stock liquidity. Exploiting the variations in the corruption environments among provinces in China, the main finding of this work is that political corruption has a substantial, negative relation with local firms' stock liquidity. The impact of local political corruption on stock liquidity is more pronounced for firms that are more reliant on political favors and/or corruption-prone. In particular, political corruption explains stock liquidity through both information and investors' trading activity channels. Further analysis shows that because of increased stock illiquidity, firms located in highly corrupt areas are associated with more reliance on short-term debt. These results highlight the negative externalities of political corruption on financial market quality.

What have we learned from this thesis that we didn't know? The primary new knowledge stems from investigating a representative emerging market, China, in its transition to an open economy and focus the role of government in the transition. In this context, the first contribution is to shed new light on the general studies on the influencing factors of CSR. Existing papers discuss how firm managers' characteristics and private benefits (Masulis and Reza, 2015; Cronqvist and Yu, 2017), institutional investors (Dyck et al., 2019) affect firms' CSR activities. We show that stakeholder pressure represented by governments plays a significant role in terms of CSR strategies.

The second contribution is to adds to the literature about the effect of CSR in trust-building. The general explanation is that CSR can build trust among various stakeholders such as governments, which can help temper their negative judgments and punishments when adverse events occur (Godfrey, 2005). However, prior research on CSR from the risk management perspective has focused on the relationship between prior-event CSR and post-event firm value. Studies find that a firm's prior-event CSR is associated with smaller decreases in firm value as a result of adverse events, which could be caused by both internal and external factors. The role of prior-event CSR is only half of the picture. It remains unclear whether firms proactively use CSR to defuse the trust crisis caused by adverse events. Taking advantage of the unexpected shocks of pollution emergencies, this is the first study to examine firms' post-event CSR strategies. In particular, we examine whether firms engage in more CSR activities after pollution emergencies and what are the resulting benefits, which add the literature on prior-event CSR.

The third contribution is to highlight how firms in China respond to environmental emergencies. Existing research finds that firms respond to the negative environmental sentiment after an environmental disaster by increasing environmental disclosures and improving environmental performance, which is just one aspect of the CSR. However, people's impressions of a firm are often assessed in one mental accounting, which is the sum of various sub-indicators of CSR. This means that “firms can adopt unrelated spheres to maintain their reputations by offsetting some bad perceptions with some good actions”. For example, after environmental misconduct is revealed, firms tend to use charitable donations as a countermeasure to mitigate the negative impact (Du, 2015; Wu et al., 2021). We find in the context of China, firms put effort into every dimension of CSR following regional pollution emergencies, including greater accountability to shareholders, employees, the supply chain, the environment, and society at large to gain trust from stakeholders, which expands the understanding of firms’ CSR strategy in emerging market.

The fourth contribution is to show the effectiveness of the public environmental regulation, that is, the relationship between green credit policy and high-quality environmental innovation. Existing literature explores the effect of green credit policy s on debt financing, firm performance, and total factor productivity (Liu et al., 2019; Zhang and Vigne, 2021; Yao et al., 2021; Wen et al., 2021). Different from them, this chapter focuses on high-quality environmental innovation as measured by environmental invention patents, which aims to promote technological progress and can be regarded as effective innovation (Du et al. 2022). This study finds a negative relationship between green credit policy and high-quality environmental innovation. Additionally, this chapter shows the compliance costs channel and bank credit allocation inefficiency are two channels through which green credit policy impedes high-quality environmental innovation. These findings add to the debate on whether environmental regulation can contribute to a green transition.

A fifth contribution of our work is to empirically examine the effect of the policy mix of green credit policy and government subsidy, given that government subsidy is a commonly used policy instrument in China. The lack of empirical studies on policy mix constitutes a remarkable gap because many countries have various policy instruments to promote environmental innovation. Basically, green credit policy is used to regulate firm emissions, and subsidies are used to support environmental transformation. However, the interaction effect of joint policies on the development of environmental innovation remains largely unverified. This chapter complements the research gap by showing that a combination of environmental policies can correct the shortcomings of a single policy. A comprehensive analysis of the effects and mechanisms can facilitate the design of environmental innovation incentives and maximize social welfare.

A sixth contribution of the thesis is to add to the literature on the determinants of stock market liquidity. Broadly, studies have focused either on firm-level characteristics (Brockman et al., 2009; Ng, 2011; Pham, 2020) or on stock market structure (Christie and Huang, 1994) to explain stock liquidity. Several papers document that stock liquidity can be affected by institutional features such as investor protection laws (Chung, 2006), policy uncertainty (Nagar, 2019) and a country's overall macro-level political institutions (Eleswarapu and Venkataraman, 2006). This thesis supplements existing studies by regarding political corruption as another important institutional factor in determining stock liquidity.

The final contribution is to expand the research on the effect of public governance especially in terms of corruption. Because of survey data availability, extensive research on corruption focuses on international settings (Wu, 2006; Barkemeyer et al., 2018; Ferris et al., 2021). However, research based on a single country has advantage in controlling for institutional (e.g., investor protection) and cultural (e.g., attitudes toward corruption) differences at the national level (Fisman and Gatti, 2002). Further, compared with developed countries, typically with low corruption, China characterized by widespread corruption provides an ideal setting to study the effect of corruption. Based on Chinese background, there has been a growing literature study the effects of corruption and anticorruption campaign on the economy and financial markets, such as efficiency of capital and labor allocation, corporate social responsibility, price discount in land transactions, innovation, corporate investment, stock price crash risk, and firm value (Giannetti et al., 2021; Hao et al., 2020; Xue et al., 2022; Chen and Kung, 2019; Xu and Yano, 2017; Fang et al., 2022; Pan and Tian, 2020; Chen et al., 2018; Xu, 2018). This chapter contributes to existing literature primarily by documenting the adverse effects of corruption on stock market liquidity. In addition, our use of Bartik-style instrumental variable that combines changes in levels of corruption by year and the local historical dishonest behaviors during Great Leap Forward period represents a methodological contribution, as this approach helps address the thorny endogeneity issues. Furthermore, by empirically testing the economic consequence of Rule 18, a significant anti-corruption regulation, this thesis adds to the growing literature devoted to examining the effectiveness of anti-corruption campaign led by Xi.

What are the possible limitations to this work? This thesis is conducted in the single-country context of China. A potential concern with these inferences is that the Chinese setting may not be representative of other emerging and developed countries. Although government engagement in business activities is a common feature in many countries, the government intervention in China is more prevalent. In China's transformation to a market economy, the traditional “iron hand” of government has not been entirely relinquished. It is possible that the effect of political pressure, public environmental policies and political governance may be less pronounced in other countries. In addition, different countries may have followed different paths in their transition and they may face different critical issues in development. Problems of environmental pollution and political corruption may not be given much attention in other countries. As a result, pollution emergencies, green credit policy, government subsidies, and political corruption in other economies may have different implications on behaviors and performance at the firm level. The other concern is that the evolving nature of a firm’s external environment makes it difficult to empirically isolate the impact of a particular factor on corporate outcomes. Keeping this in mind, we perform several additional and robustness tests to verify the validity of the findings.

How can future research build on this thesis?

The limitations of this thesis open avenues for future research. First, our results may not be applicable to countries where markets, instead of the government, play a fundamental role in allocating resources, where political intervention do not prevail. Researchers may investigate whether these findings different in other national contexts which might differ in terms of their institutional pressures and environmental progress and political governance.

Second, as discussed before, government is typically the most important stakeholder of firms beside firm owners in emerging markets. while this study focuses on the issue of political pressure, public policies and political corruption, future research can further examine how these effects are contingent on other dimensions of local institutional condition. For example, more research is needed to understand the incentives of government in its relationship with firms under its jurisdiction and how the incentives would further influence the degree of political pressure and effectiveness of policy implementation and the negative impact of policy corruption. This needs to be based on an analysis of the political system and an understanding of how officials are paid and promoted and how misconduct is detected and punished. The political system, in turn, affects the motivations, methods and extent of government intervention in firms.

Third, existing academic work primarily measures corruption from a government perspective. However, as the main body of bribery, firms play an indispensable role in many corrupt behaviors. There are different forms of corruption, including bribery, graft, tax evasion, vote buying, favoritism, and cronyism with different purpose. It would be interesting to identify heterogeneous effect of corrupt behaviors form perspective of firms with different motivations. Another research issue related to political corruption is the anti-corruption campaign in full swing in China. After the anti-corruption campaign, government officials are disciplined more rigorously than before. Some government officials are unwilling to work as hard as before, so called ‘inertia and negligence’, because working harder will not recoup their lost illicit income and may even increase the chance of making mistakes in their routine work. Thus, examining how the work efficiency of government officials is affected by the anti-corruption campaign is an interesting research topic. The corruption in public procurement is also potential research issue. Cases of convicted corrupt officials indicate that allocation of public procurement opportunities is a channel through which many of them obtain bribes. Corrupt officials often seek to offer business opportunities in public procurement to firms that bribe them. Once public procurement data are available, corruption in public procurement and its economic consequences can be explored.

Finally, this thesis is based on listed firms. Although China has more than 3,000 listed firms, it is still just the tip of the iceberg. According to statistics from the State Administration for Market Regulation, as of the end of 2018, there were more than 30 million registered firms. The situation of unlisted firms needs to be explored: for example, compared with listed firms, are unlisted firms differently affected by political pressure, environmental policies, and political corruption? More or less? Listed firms can learn from unlisted firms and vice versa.

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