TRANSFORMATION TO GREEN ECONOMY: THE IMPACT OF PUBLIC POLICY, STATE OWNERSHIP, AND MARKET MECHANISM

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Transformation to Green Economy: The Impact of Public Policy, State Ownership and Market Mechanism

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CERTIFICATE OF ORIGINALITY

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Abstract

The dissertation aims to investigate the forces of government-led mechanisms and market-driven instruments in facilitating green transformation in China. Two types of government-led incentives are examined: incorporating carbon emissions reduction targets into cadre evaluation of local governments and enforcing carbon neutrality goals through decarbonisation efforts by state-owned enterprises (SOEs). Firstly, the dissertation investigates the effect of China's central government as the authoritative body on mandating local governments to implement decarbonisation policies by incorporating green targets into cadre evaluation. The introduction of green building policy is investigated. The empirical results indicate that the introduction of the green building action plan into the local government target responsibility system spurs the local development of green buildings. Mechanism analysis indicates that the integration of green building targets into performance evaluation metrics of local officials increases government environmental attention, public environmental concerns, and financial incentives to support green building development, thereby encouraging proactive engagement in green building initiatives. However, the heterogeneity analysis shows that the policy only promotes green building development from the public sector but does not significantly affect green building behaviours in the private sector. The inadequacy to motivate the private sector to engage in green transformation limits the policy's overall impact.

Secondly, the dissertation investigates whether and how the government can achieve carbon neutrality goals by engaging SOEs. SOEs are significant polluters and carbon dioxide emitters; meanwhile, countries rely on SOEs' involvement to meet their climate commitments and achieve successful decarbonisation. On 22 September 2020, China committed to reaching peak carbon emissions by 2030 and carbon neutrality by 2060. Based on this event, the dissertation investigates whether SOEs will fulfil national carbon neutrality tasks to a greater extent than non-SOEs by examining market reactions to the announcement of the national carbon neutrality goals. Empirical results show that investors perceive SOEs as responsible for achieving carbon neutrality, leading to more severe negative market reactions than non-SOEs. Central SOEs are more responsive to the central government's carbon neutrality commitment than local

SOEs. Furthermore, SOEs with greater social responsibility could be more likely to actively comply with green transformation requirements and allocate substantial funds towards industry upgrades and carbon emission reductions; thereby, they experience stronger negative market reactions. Following the commitment to carbon neutrality, SOEs' carbon emission intensity has significantly declined compared with non-SOEs. These findings suggest that state ownership could be an effective mechanism for green transformation.

The dissertation demonstrates that government-led green transformation mechanisms incentivise local governments and SOEs through administrative means and assigned tasks. However, their effectiveness in promoting green transformation could be limited, as these policies may fail to stimulate the engagement of the private sector, which also possesses resources and influence to drive the industry's green transformation. Market-driven instruments could be crucial in motivating private firms to pursue green initiatives. Against this backdrop, the dissertation investigates the effectiveness of an important market-based tool, the issuance of green bonds, in the corporate green transition, and focuses on the impact of third-party verification in firms' involvement on green bond issuance and the use of proceeds in green projects in the post-issuance periods. Results reveal that issuing certified (non-certified) green bonds results in favourable (non-significant or even negative) stock market reactions in both the short and long term, indicating that third-party certification generates financial benefits to firms involving genuine decarbonisation efforts. Certified green bonds provide more detailed and accurate information, reducing information asymmetry. Furthermore, third-party monitoring of certified green bonds prevents funds from being allocated to non-green projects and discourages superficial green practices, thereby mitigating greenwashing and improving environmental performance. Empirical results also indicate that third-party certification enables firms to attract long-term investors, increase analyst coverage, and receive positive recognition from regulators. Carbon intensity is reduced more when green bond issuers are certified. In sum, the dissertation shows that market-based instruments have the potential to facilitate corporate green transformation, induce genuine decarbonisation efforts, and enhance firm value.

The significance of the dissertation can be attributed in three ways. First, it offers unique insights into the impact of government-led policies on national green transformation. The results indicate that local governments actively engage in green initiatives in response to the central government's strategic plan, although their impacts on engaging the involvement from the private sector are limited. SOEs serve as another crucial conduit for government green transformation. The negative market response to SOEs substantiates investors' belief that SOEs will play a pivotal role in China's green transformation. Secondly, this study advocates using market-driven instruments to facilitate green transformation. Instruments such as green certification can augment firm value and environmental performance, motivating firms to participate in green initiatives. Lastly, the dissertation has broader implications for achieving a green transition. In a command-and-control system, the central government can exert control and issue directives to local governments and SOEs to promote regional and corporate green transformation. For emerging economies lacking market participation, the dissertation confirms that a market-driven green economy is a long-term mechanism for firm sustainable development. Overall, the dissertation affirms the force of public policy, state actions, and market drivers in green transformation. It furnishes crucial insights for decision-makers pursuing a green economy globally.

List of Publications

- **Papers arising from the thesis**

Yu, Q., Hui, E. C. M., & Shen, J. (2024). The real impacts of third-party certification on green bond issuances: Evidence from the Chinese green bond market. *Journal of Corporate Finance*, 102694.

Yu, Q., Hui, E. C., & Shen, J. (2024). Are state-owned enterprises more responsible for carbon neutrality? Evidence from stock market reactions to China's commitment to carbon neutrality. *Journal of International Financial Markets, Institutions and Money,* 96, 102055.

- **Manuscripts under preparation**

Yu, Q., Hui, E. C. M., & Shen, J. (Under preparation). Promoting Local Green Practices through Target Responsibility System: Evidence from China's green building action plan.

- **Other publication**

Yu, Q., Hui, E. C. M., & Shen, J. (2023). Do local governments capitalise on the spillover effect in the housing market? Quasi-experimental evidence from house purchase restrictions in China. *Land Use Policy*, *133*, 106851.

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DEDICATION

To my beloved parents.

Table of Contents

List of Figures

List of Tables

Chapter 1. Introduction

1.1. Research background

1.1.1. China carbon neutrality commitment

The overuse of fossil fuels results in carbon dioxide emissions, which contribute to global warming and threaten economic stability (Bolton and Kacperczyk, 2021). To combat this problem, there is an increasing worldwide emphasis on developing a low-carbon environmental model as a substitute for the current high-carbon development approach (Kaminker and Kawanishi, 2013). Following the Paris Agreement, both market mechanisms and government efforts have contributed to reducing carbon emissions worldwide. On 22 September 2020, China committed to reaching peak carbon emissions by 2030 and carbon neutrality by 2060. This was the first announcement of China's long-term goal to achieve carbon neutrality, and the stated target is bolder than the expectations of many researchers (Krolewiecki, 2020). Following this ambitious commitment, China faces challenges such as reducing its reliance on fossil fuels, upgrading its industries and adjusting its economic structure (Krolewiecki, 2020; Liu et al., 2022).

China has been the world's largest emitter of carbon dioxide since 2006. Figure 1.1 illustrates that China's carbon emissions, measured from an output perspective, reached 2.173 billion tons in 1990. By 2020, this figure had risen by 403% to 10.945 billion tons. Over the years, China's share of global carbon emissions has consistently increased, from 10.21% in 1990 to 32.61% in 2020. Although China leads in total carbon emissions globally, its per capita emissions are relatively low. Figure 1.2 shows an increase in China's per capita carbon emissions from 1.91 tons in 1990 to 7.76 tons in 2020. Compared to the United States and other OECD countries, China's per capita emissions are on an upward trend. Meanwhile, the per capita emissions in these countries have been declining since 2000. Even though China has a low per capita emission rate, the total amount continues to increase as the economy develops and living standards rise. China faces significant challenges in managing carbon emissions due to these trends. Therefore, China must adopt more proactive measures to address climate change and reduce carbon emissions. It will significantly contribute to China's sustainable development goals and global climate goals (Zhang et al., 2024). Both market-based and non-market-based mechanisms are needed to be adopted to realize the ambitious goal of carbon neutrality. China's green transformation is distinguished by the government's proactive and even leading role in the process.

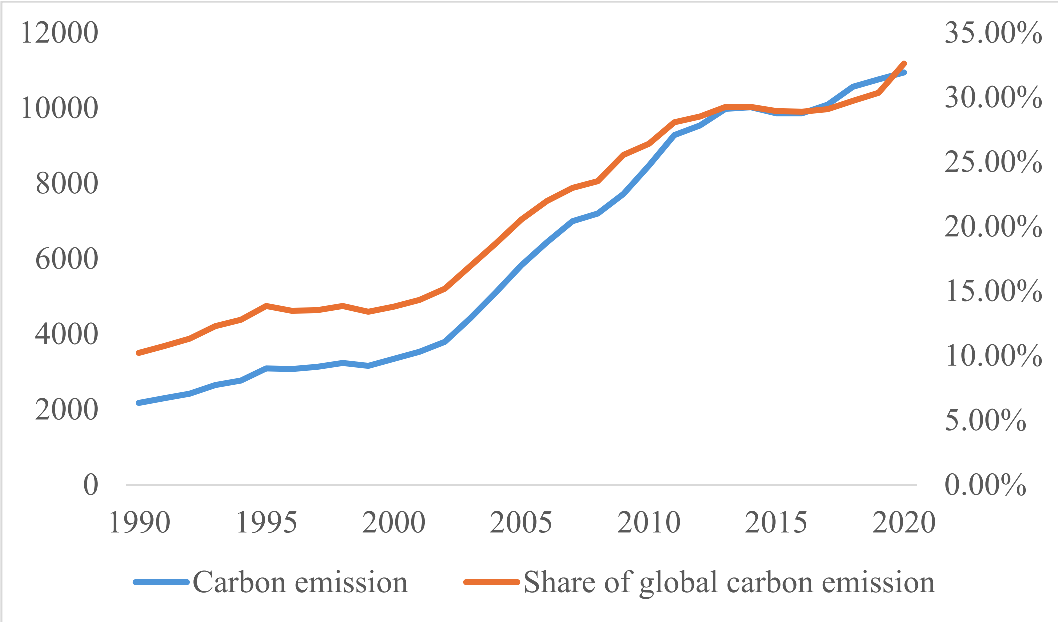

Figure 1.1 The carbon emission of China and its share of global carbon emission from 1990 to 2020. **(Source: World Bank)**

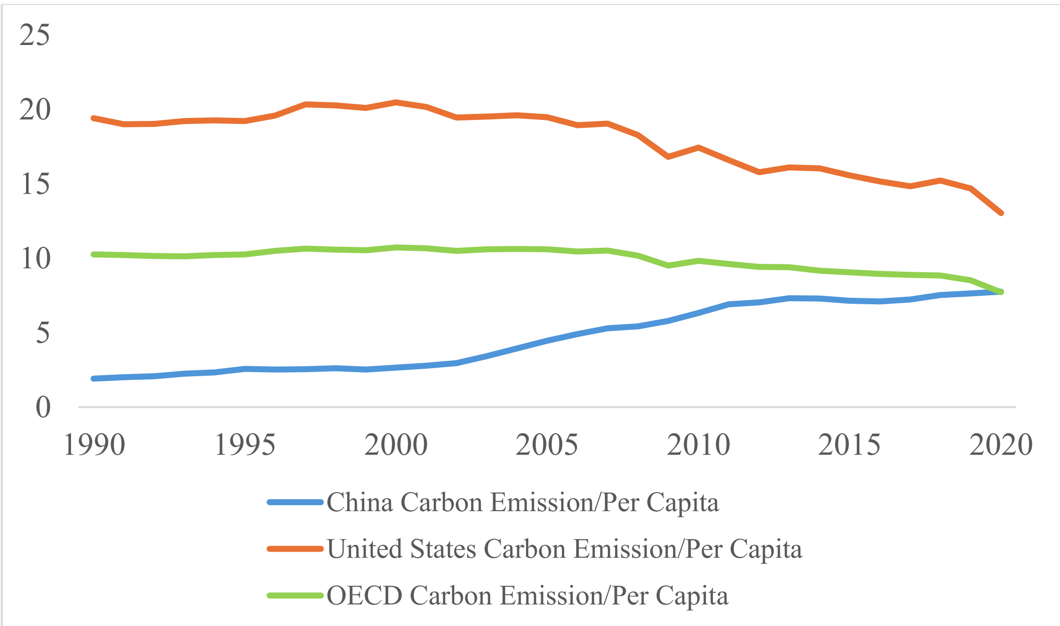

Figure 1.2 The per capita carbon emission of China, United States and OECD countries from 1990 to 2020. **(Source: World Bank)**

1.1.2. The government-led green transformation

China's economic development and environmental governance models entrust local governments with implementing national goals and strategies. The central government conducts periodic evaluations to assess the performance of each province, creating both incentives and pressure. Environmental governance initiatives directed by the central government and executed by local authorities have achieved substantial progress over recent decades (Zhang et al., 2018). For example, China's water quality regulation program has resulted in a 57% reduction in chemical oxygen demand emissions from upstream firms (He et al., 2020). Considering growing smog concerns, China established a nationwide program to monitor and disclose air quality in real time. The program has resulted in a 40% reduction in PM2.5, a 65% reduction in sulphur dioxide (SO_2), and a 33% reduction in carbon dioxide emissions (Greenstone et al., 2021). In addition, it has increased public access to pollution information (Greenstone et al., 2022) and reduced air pollution-related deaths by almost 7% (Barwick et al., 2024). These initiatives have successfully reduced industrial wastewater pollution and improved air quality and environmental quality. However, local leaders remain weakly motivated to curtail polluting activities, resulting in a social cost borne by downstream neighbours (Kahn et al., 2015; He et al., 2020). The self-financing system encourages local governments to participate in activities that benefit economic development and local fiscal revenue rather than low-income public services, such as environmental protection (Oi, 1992; Qian and Weingast, 1997). Therefore, the critical question is whether the central government can effectively mandate green economy transformation tasks to local governments through administrative orders.

Beyond assigning green transformation targets to local authorities, the central government in China has assessed another powerful lever: SOEs. SOEs play multiple roles in the national setting and are critical components of the Chinese development model with dual economic and societal attributes (Lin et al., 2020). 97 central SOEs are directly supervised by the State Assets Supervision and Administration Commission of the State Council (SASAC), and more than 10,000 local SOEs are managed by local governments. The total assets of SOEs amount to 33.95 trillion yuan, contributing nearly 30% to GDP annually and accounting for 29.12% of tax revenues. However, SOEs are primarily concentrated in carbon-intensive industries such as petrochemicals,

chemicals, building materials, steel, non-ferrous metals, papermaking, power, and aviation. These industries contribute to 80% of China's carbon emissions. In other words, SOEs are responsible for China's lion's share of carbon emissions.

In September 2020, China committed to reaching carbon neutrality by the mid-21st century. As a result, SOEs have a crucial role in reducing CO2 emissions in China. However, there has been a debate over whether SOEs outperform non-SOEs regarding environmental performance. Studies suggest that SOEs are more responsible for solving environmental issues and climate change mitigation than non-SOEs (Hsu et al., 2023; Mayer et al., 2017). SOEs provide governments an open channel to achieve environmental and social goals (Clò et al., 2017). However, SOEs may be less efficient in reducing carbon emissions than non-SOEs. This may hinder a country's carbon mitigation goals (Andersson et al., 2018). Furthermore, SOEs may be less likely than non-SOEs to face inspection by government agencies, or they may be more capable of circumventing environmental regulations due to their closer connections with governments (Zhang, 2017). Therefore, it is unclear whether state ownership can facilitate a low-carbon green transformation.

1.1.3. The market-driven green transformation

Government-led transformation lacks external public participation and ignores market forces and firm demands (Gilley, 2012). Politically generated policy paths may fail to achieve a green transition when this is economically undesirable. For example, pursuing economic benefits and cadre promotion has led local governments to establish highly polluting firms in environmental sanctuaries far from monitoring stations (Chen et al., 2018). In addition, environmental monitoring only provides temporary relief from covert pollution since firms unlawfully discharge pollutants due to the high cost associated with mitigation efforts (Agarwal et al., 2023). Besley and Persson (2023) argue that policy should act as a facilitator rather than the primary driver of the green transition, which is fundamentally driven by markets and firms as economic actors. Given government-led policies' limitations, market-based voluntary emission reduction and environmental protection measures are emerging within the private sector (Arimura et al., 2011).

Decarbonization activities in developed markets are mobilized through various market-based instruments, such as emissions trading, green finance, corporate environmental, social and governance (ESG), and certification. Market mechanisms drive firms to disclose extensive environmental information and positively respond to public and stakeholder demands for enhanced environmental performance (Qian and Schaltegger, 2017). Voluntary initiatives enhance the value and legitimacy of firms while reducing the risk of their collapse. Although market-driven activities can benefit both firms and stakeholders, some challenges are raised by market practices, such as greenwashing and ESG washing. Corporate greenwashing costs are minimal, as presenting selective environmental information fosters a sustainable image. While market mechanisms are intended to alter organizational behaviour, concerns about their legal enforceability raise concerns about their effectiveness in improving environmental performance. Therefore, it is imperative to examine whether market-based approaches can genuinely encourage corporate engagement in green transformation.

1.2. Research questions

The achievement of green transformation is vital for reducing greenhouse gas emissions (Besley and Persson, 2023). Addressing environmental issues necessitates a fundamental shift from a high-pollution, high-emission development model (Chen et al., 2022). In this context, the state's role has been reemphasized. The state can provide political incentives and invest in technological innovation for a green transition. Market mechanisms are also a key component of green transitions, encouraging firms to adopt green technologies and produce green products to meet consumer demands. The dissertation aims to investigate the impact of government-led and market-driven approaches on promoting green transformation. Specifically, the dissertation will address the following two questions: (1) What are the effects of government-led restrictive policies on green transformation at the regional and corporate levels? (2) What roles do market-driven instruments play in facilitating corporate green transformation? The first question focuses on the force and effectiveness of government-led green transformations, while the second question concerns the benefit of market-driven corporate green transformation.

1.3. Research objectives

The research questions above naturally lead to two distinct goals for this dissertation. The first goal is to evaluate how government-led policy promotes regional and corporate green transformation in China, focusing on exploring unique Chinese characteristics, such as using a cadre evaluation system to promote economic and social goals and the dominance of SOEs in the economic system. Specifically, the dissertation can deal with this goal by way of achieving the following two research objectives:

1. To assess the effectiveness of government target responsibility policy in promoting regional green development;

2. To investigate the impact of state ownership on the achievement of the state's commitment to carbon neutrality goals;

The second is to investigate how the market-driven instruments stimulate green transformation from a market perspective. This objective can be subdivided as follows:

3. To examine the effect of market-driven instruments on corporate green transformation behaviour.

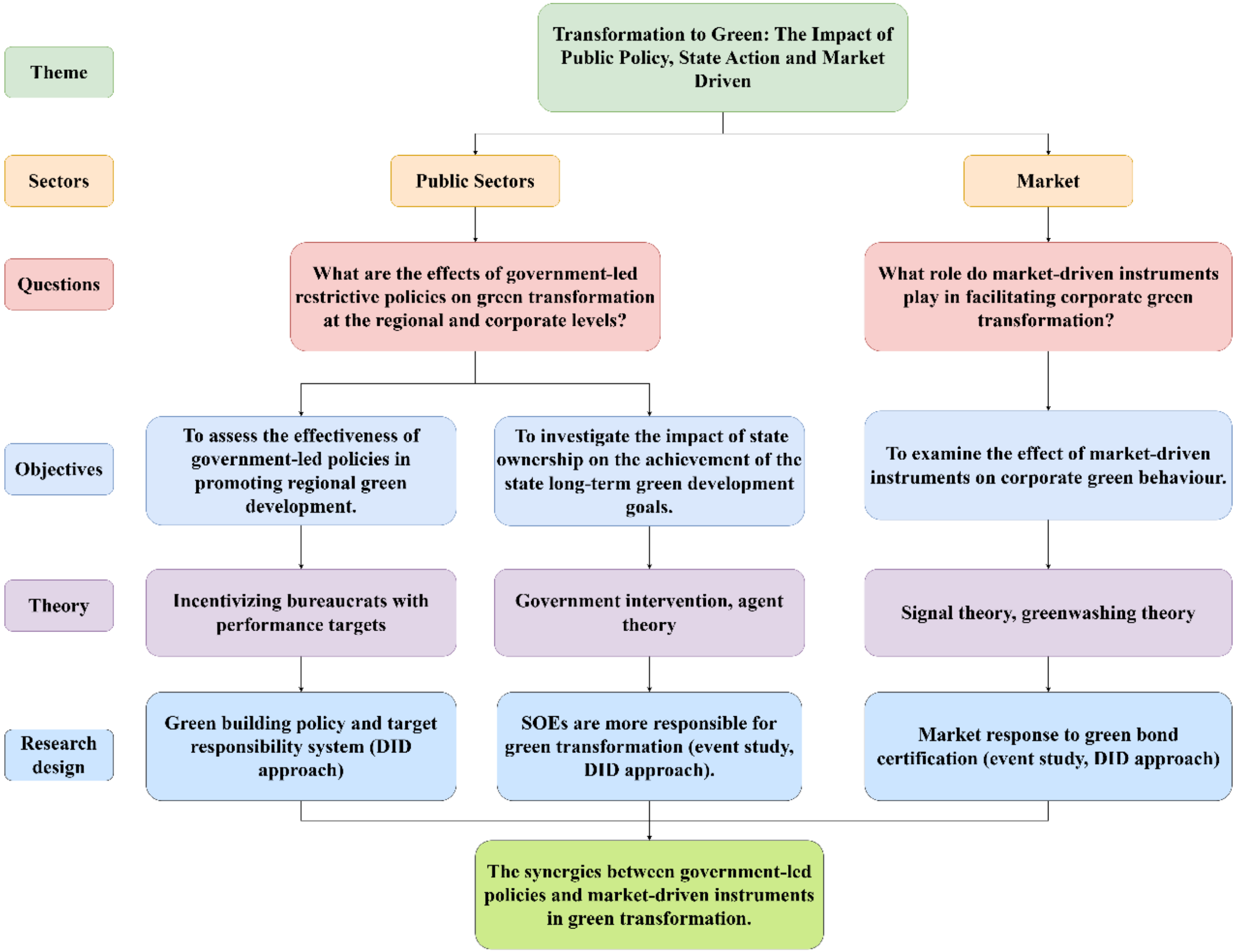

Figure 1.3 Research objective

1.4. Research significance

The dissertation significantly contributes to a better understanding of the force of government-led policy on the progress of national green transformation. While it is not the first to empirically explore the relationship between environmental performance and the local government target responsibility system in China, it offers a unique focus on how local governments can effectively implement carbon reduction policies through targeted responsibility actions in cadre evaluation. Previous studies suggest that the target responsibility system in cadre evaluation can motivate local governments to adopt environmental regulations, thereby reducing pollution (Zheng et al., 2014; Wu and Cao, 2021). The dissertation is distinguished by examining the effectiveness of the target responsibility system in implementing a carbon reduction policy. In pollution abatement governance, prolonged exposure to air pollution diminishes citizens' satisfaction and trust in local government performance (Alkon and Wang, 2018). Lower political trust reduces local officials' chance of being promoted, motivating them to mitigate air pollution (Yao et al., 2022). In contrast, carbon emission reduction is primarily a guiding concept without specific targets, and both local governments and the general public lack a comprehensive understanding of low-carbon development (Zhang et al., 2024). The dissertation suggests that incorporating green targets into cadre assessments can effectively promote green building practices and reduce urban carbon footprints.

State ownership also serves as an effective channel for government intervention, enabling SOEs to achieve their green goals. Compared with private enterprises, SOEs are more motivated to pursue collective interests, leading to better environmental performance (Clò et al., 2017; Zhang, 2017; Liang and Langbein, 2021). However, other studies show that SOEs can negotiate with governments for less stringent regulatory enforcement, potentially dampening their pursuit of environmental goals. Accordingly, SOEs may have lower environmental performance than non-SOEs (Meyer and Pac, 2013). The research provides new empirical evidence regarding state ownership and green transformation. The market considers SOEs to be faithful implementers of environmental policies, responding with more negative market reactions than non-SOEs to the government's carbon neutrality commitments. SOEs will become the backbone of the green transformation. In contrast to research on the ability of carbon policies to achieve carbon neutrality (Dong et al., 2022; Yu and Zhang, 2021), the examines the forces that contribute to the realization of carbon neutrality commitments. Empirical results reveal that SOEs are essential to carbon neutrality. SOEs have implemented active strategies to reduce emissions to fulfil the commitment to carbon neutrality. This is first study to demonstrates that central SOEs can expand their responsibilities in this area. Empirical results indicate the market's belief that CSOEs will actively respond to the central government's commitment to carbon neutrality.

The dissertation contributes to the market-driven green transformation path, highlighting self-certification as an essential tool to facilitate corporate green transformation. Several studies have demonstrated that market-based environmental regulation can promote technological innovation and private-sector upgrading (Arimura et al., 2008; Ferrón-Vílchez, 2016; Hu et al., 2021; Neagu et al., 2024). Alongside government-led environmental policies, market-based strategies are crucial for encouraging private-sector engagement in green practices and enhancing regional sustainability. Market-driven instruments can enhance firm value, improve environmental performance, and benefit investors in the short and long term. Prior studies have focused on market responses to green bond issuance, capital cost reductions, and the reliability of environmental signalling commitments (Zerbib, 2019; Larcker and Watts, 2020; Tang and Zhang, 2020; Flammer, 2021; Pástor et al., 2022). Yet, no research has been conducted on the impacts of third-party certification of green bonds on corporate green transformation. The dissertation fills this gap by investigating the real effects of third-party green bond certification, documenting that certification can facilitate corporate green transformation and enhance firm value. Specifically, it is a powerful tool to attract long-term investors who prioritise environmental sustainability and enhance a firm's overall value. Moreover, certification has tangible environmental impacts because it positively influences a company's ESG rating and safeguards against corporate greenwashing. The dissertation shows that market-driven instruments can actively motivate firms to participate in the green transition.

The dissertation has broader implications for a green transition. The market and state failures can impede the achievement of a green transition (Besley and Persson, 2023). The dissertation confirms the synergy between government-led policies and market-driven instruments in the green economy transition. Whereas developed countries often rely on market and financial mechanisms to encourage companies to reduce environmental pollution and emissions, China frequently employs top-down environmental policies (Marquis and Bird, 2018; Teets, 2018; van der Kamp, 2021). The target responsibility system has effectively enhanced local governments' responsiveness to the central government's green transition mandate. Additionally, pervasive state ownership in China's economic system allows the government to direct SOEs to adopt low-carbon measures (Mayer et al., 2017). Empirical results indicate that state ownership is a reliable force that promotes the decarbonisation of an economic system dominated by state ownership. However, this model fails to mobilise the private sector's enthusiasm. Market-driven green transformation is a long-term mechanism for conserving energy and reducing emissions for firms based on the evolution of green transformation methods and their actual results (Bai et al., 2023). The dissertation demonstrates that firms' self-environmental certification behaviours can help bridge the information gap between companies and investors, ensuring genuine compliance with environmental commitments and facilitating green transformation instead of greenwashing.

1.5. Chapter layout

The dissertation consists of five chapters that address three research objectives. The layout section summarises the methodologies and findings presented in these chapters.

Chapter 2 overviews the relevant literature and establishes the research framework. This chapter discusses the government-led policy, market-driven instruments for environmental regulation, and environmental and sustainable development. A research framework is also proposed by summarising and discussing previous studies.

Chapter 3 investigates the impact of China's central government as the authoritative body on mandating local governments to implement decarbonisation policies through incorporating green targets into the target responsibility system. In particular, this chapter employs the difference-in-difference (DID) method to investigate the causal effect of integrating green building objectives into the target responsibility system. It analyses how the green building target responsibility system promotes local green practices. By doing so, the impact of government-led green policies on promoting local green transformation can be assessed, which achieves research objective 1.

Chapter 4 examines whether and how SOEs, as government agents, can achieve national green transition goals. A market and market adjustment model is used in this chapter to measure and compare market reactions to SOEs and non-SOEs under China's carbon neutrality commitment. In addition, this chapter discusses how administrative distance and corporate social responsibility affect market responses to SOEs. The long-term impact of carbon neutrality commitments on SOEs is also assessed using a Difference-in-Difference approach. These analyses address whether SOEs bear greater responsibility for achieving the country's carbon neutrality commitment, thus fulfilling research objective 2.

Chapter 5 examines how market mechanisms, such as corporate certification, can facilitate corporate green transformations. This chapter examines the real effects of third-party certification on green bond issuance by Chinese listed firms over the 2016-2022 period. The event study method is employed to investigate the stock market's reaction to the issuance of green bond in the short and long term. The dissertation analyses the underlying mechanisms that drive the value creation of third-party certification in green bond issuance. Empirical results can answer whether the market-based tool can generate real economic benefit and facilitate corporate green transformation, thereby achieving research objective 3.

Chapter 6 summarises the research findings from the previous chapters. The objectives of the dissertation will be revisited to understand the government's and the market's role in green transformation. Furthermore, the chapter discusses the implications of the findings for policymaking and the direction of future research.

Chapter 2. Literature Review

This chapter reviews existing studies on government policies and market mechanisms, forming the foundation of the research framework. Sections 2.1 and 2.2 examine the roles and challenges local governments and state-owned enterprises faced in past environmental governance. The following section investigates market mechanisms, highlighting knowledge gaps. Finally, this chapter illustrates how the research framework supports the objectives.

2.1. The central government command and the local government response model to green transformation

Local governments have gradually embraced a new urban governance model that emphasizes sustainable development, aiming to transform green and low-carbon societies. The section reviews local governments' responses to the central government's directives on environmental governance. Local governments have been actively fulfilling the central government's environmental mandates. However, they face multiple policy objectives set by higher authorities and often lack the necessary resources to implement them. Consequently, when budgets are tight, local governments must prioritize and selectively implement specific policy goals. This circumstance may create a favourable environment for high-pollution enterprises, referred to as a "pollution paradise". The dissertation also examines the relationship between promotion incentives for Chinese officials and the environmental responsibility of local governments. Numerous studies indicate that the central government rewards green behaviour through cadre evaluation. However, local officials still prioritize economic development due to disparities between national policy goals and local bureaucratic incentives. This misalignment can lead to law enforcement manipulation to reduce production costs for firms. Consequently, a debate exists about whether China's top-down target responsibility system can facilitate green transformation.

2.1.1. Central environmental regulations and local government implementation

The vertical relationship between China's central government and local governments has led the central government to outsource most public services, such as environmental protection and social security, to local governments with apparent spillover effects (Li and Zhou, 2005). Local governments are responsible for implementing these public services (He et al., 2020). The central officials have become aware of environmental issues in economic development and have published various policies, laws, and regulations to address the environmental crisis (Wu and Cao, 2021). Significant developments have been in China's environmental governance, such as the Low Carbon City Pilot Program, an important national initiative to promote climate experimentation and develop innovative climate solutions (Lo et al., 2020). Prior studies examine the effectiveness of implementing a low-carbon city pilot program. Yu and Zhang (2021) assess the impact of this policy on carbon emission efficiency by examining emissions data from 215 Chinese cities between 2003 and 2018. According to their findings, this program results in an increase in carbon emission efficiency by 1.7%. This is the equivalent of approximately 8.37 million metric tons of CO2 reductions. Energy conservation and emission reduction policies compel firms to invest in green technology, reduce reliance on non-clean energy sources, and lower carbon emissions by decreasing energy consumption and intensity (Feng et al., 2021; Xu et al., 2022). In addition, previous research documents that establishing automatic air pollution monitoring stations by local governments has enhanced the accuracy of atmospheric pollution reports and local air quality (Ghanem and Zhang, 2014).

The top-down approach to these initiatives has been criticised for specific limitations. Challenges in developing genuinely low-carbon green cities arise from the absence of clear definitions, complexity and confusion resulting from parallel projects, and the lack of supportive market-based mechanisms (Khanna et al., 2014). Zhang et al. (2024) report that the voluntary carbon emissions reduction policies do not lead to a reduction in per capita greenhouse gas emissions. This suggests that policies without binding targets lack sufficient enforcement and cannot genuinely meet green transformation requirements. China has comprehensive environmental legislation. However, its enforcement at the local level remains an issue (Van Rooij, 2006). Local governments may exercise enforcement discretion to protect polluting firms (Jia and Nie, 2017). For instance, Ghanem and Zhang (2014) reveal that local governments manipulate air pollution indexes near the threshold for acceptable air quality. The local government also strategically locates heavily polluting firms in downwind areas based on wind direction and atmospheric transport characteristics, thereby reducing pollution detected by the monitoring network and reducing pollution exposure for residents in urban areas. Moreover, due to the mobility of firms, jurisdictions with less stringent environmental regulations attract highly polluting industries. Zhu et al. (2014) observe that China's pollution-intensive firms have relocated from coastal provinces to inland regions with less stringent environmental regulations.

In a system of environmental decentralization, the central government retains political authority for environmental planning while delegating most basic law enforcement responsibilities to local governments. Several previous studies have demonstrated that local governments have relaxed environmental regulations to reduce production costs for firms (Ghanem and Zhang, 2014; Jia and Nie, 2017). The central government has intensified supervision and punishment for environmental law enforcement to bridge the gap in environmental governance willingness and action between the central and local states. Zhang et al. (2018) investigate China's recent environmental regulation reform by examining the national critical monitoring firm project, revealing that direct central supervision has a significant short-term impact on the environment, reducing industrial water pollution by at least 26.8%. According to Chen et al. (2022), a centrally designed environmental protection inspection centre will encourage firms to reduce pollution. Firms under supervision reduce their chemical oxygen demand (COD) emissions by 16.30%. Moreover, the environmental inspection centre can mitigate the issue of cross-provincial pollution emissions within the supervised area, breaking the downstream effect. Generally, top-down campaign governance promotes more effectively in provinces and regions with weaker legal systems and more severe environmental pollution (Ding et al., 2022). However, this reform does not result in a centralized environmental regulatory system since the central government does not assume local regulators. It provides supervision to enhance their regulatory capacity and accountability. Local governments remain responsible for enforcing local environmental regulations, albeit with increased transparency and more substantial supervision (Zhang et al., 2018).

2.1.2. Career incentives and environmental regulations

Political connections and promotion often influence the government's willingness and ability to enforce environmental regulations (Zheng et al., 2014; Wu and Cao, 2021). The central government often promises political rewards contingent on meeting specific performance criteria. Previous studies found that the cadre evaluation system rewards local officials' green efforts. Better environmental performance will facilitate city mayor tenure promotion (Chen et al., 2018). Accordingly, Zheng et al. (2014) examine energy intensity, air pollution control expenditures, and air pollution data for 86 major Chinese cities. The study indicates that the greater the environmental performance, the greater the likelihood of a mayor being promoted. Chen et al. (2018) find that incorporating sulphur dioxide emission (SO2) quotas into the promotion evaluation of prefecture-level mayors and party secretaries significantly decreases urban SO2 emissions. Despite potential adverse effects on economic growth, local officials are closing power plants and restricting polluting industries. This assessment does not reduce other pollutants, such as carbon dioxide and wastewater. Wu and Cao (2021) examine the relationship between government environmental behaviour and promotion based on Chinese county-level data on SO2 and PM2.5. County governors and party secretaries reduce local pollution when the central government rewards green behaviour. However, their research indicates that pollution only affects the promotions of county-level officials and does not affect promotions at the prefectural or provincial levels.

Research has confirmed that local officials who exhibit green behaviours benefit their careers. However, it is widely believed that promoting economic growth is the safest approach to promoting cadres (Cao et al., 2019). Local officials promote economic development in its communities by attracting polluting industries. They have no incentive to reduce energy consumption or protect the environment in their jurisdictions because these actions do not contribute to their political career opportunities (Wu et al., 2013). Cao et al. (2019) analyse PM2.5 levels in China between 2002 and 2010. PM2.5 levels and the tenure of municipal party secretaries exhibit a U-shaped relationship. Municipal party secretaries may relax enforcing environmental regulations during their last few years in office to reduce industrial production costs, stimulate economic growth, and enhance their promotion prospects. As a result, local officials are strongly incentivised to under-enforce environmental laws.

Cai et al. (2016) investigate the activities of counties along 24 major rivers in China. Their findings indicate that downstream provinces are lenient in enforcing pollution fees, which causes a 20% increase in water pollution activities over similar counties. They introduce the concept of a downstream effect, i.e., provinces tend to enforce regulations less strictly in counties located further downstream. This practice leads to an increase in water-polluting activities at provincial boundaries downstream. This argument is supported by He et al. (2020), who demonstrate that local officials are motivated to implement stricter environmental standards for firms that operate upstream from monitoring stations. Water quality readings play an important role in political assessment, and monitoring stations only record emissions from upstream areas . As a result, polluting firms in upstream areas experience a decline in total factor productivity of over 24% compared to their counterparts in downstream areas.

2.2. State ownership and green transformation

The section reviews how governments can promote green transformation by intervening in SOEs. The government can directly participate in business decisions through SOEs instead of more costly and ambiguous tools like taxes and regulations. Initially, the dissertation discusses the role of SOEs in economic development. As government agents on the market, SOEs often have better access to credit markets and other essential resources compared to private counterparts. However, this advantage has also contributed to their poor financial performance. SOEs have a greater responsibility for social welfare when examining the environmental performance of their dual social and economic functions. However, SOEs wield superior bargaining power regarding environmental issues, which can lead to more severe pollution issues. According to previous studies, China's administrative hierarchy significantly impacts this dynamic. Local governments shelter local SOEs' polluting behaviours to foster regional economic development. Therefore, whether SOEs can effectively drive a country's green transformation remains to be determined.

2.2.1. State ownership and financial performance

As influential global economy players, SOEs are widely recognized as instrumental in implementing national development strategies (Szarzec et al., 2021). SOEs in emerging economies (such as China) differ from those in mature economies (Zhou et al., 2017). For example, the Chinese government is more influential in influencing business behaviour, including corporate strategy (Wang et al., 2008). SOEs are managed by the administration rather than by the economy's needs (McGuinness et al., 2017). Consequently, SOE strategies are often tailored to meet government needs rather than their customers. Therefore, some of the studies concentrate on the financial performance of SOEs. According to Tihanyi et al. (2019), the financial performance of SOEs is marginally affected by state ownership. Political connections significantly distort investment behaviour and undermine investment efficiency (Chen et al., 2011). Fan et al. (2013) show that SOEs adjust their strategies slowly in response to financial distress compared with privately owned firms. Some studies propose the opposite view. Tian and Estrin (2008) suggest that state ownership has a non-monotonic but U-shaped effect on corporate value. The corporate value decreases as government ownership increases but increases beyond this threshold. Matuszak and Kabaciński (2021) examine the correlation between the profitability of SOEs and the level of electricity prices in EU countries and find a significant disparity in profitability between SOEs and private firms in markets with lower electricity prices. These results suggest that the lower profitability of SOEs cannot be attributed to inefficiency; somewhat, it is influenced by social responsibility objectives that extend beyond profit maximization.

Studies also confirm that their institutional environment primarily influences SOE's financial performance. Szarzec et al. (2021) compile an extensive dataset on the share of SOEs in total assets, operating income, and employment in post-socialist European nations. The findings demonstrate that the influence of SOEs on economic growth is dependent on the quality of institutions. SOEs only promote economic growth when sufficient institutions exist (Genin et al., 2021). When well-functioning institutions are present, SOEs can contribute positively to economic development. Huang et al. (2017) find state ownership negatively impacts SOEs' outward direct investment. Institutional development and market competition mitigate the negative relationship between state ownership and outward direct investment.

State ownership can be beneficial in areas where institutional gaps exist, such as access to credit markets and other critical resources (e.g., Boyreau-Debray and Wei, 2005; Cull et al., 2015). Berkowitz et al. (2017) report that the productivity of SOEs lagged behind that of foreign and private firms. SOEs could survive because they had priority access to cheap loans from state-owned banks (Song et al., 2017). Accordingly, institutional logic emphasizes that SOEs can acquire resources to promote innovation (Pan et al., 2020). For example, by increasing investment in R&D, an economy can become more innovative (Zhou et al., 2017). Nevertheless, China's SOEs have generally been less competitive in developing innovation-related organizational capabilities than private companies due to their inefficient utilization of abundant resources (Chang et al., 2019). Patent filings by private firms are higher than those by local SOEs (Lin et al., 2021). Some studies have indicated that partial privatization of SOEs can positively affect their innovation capabilities (Tan et al., 2020; Zhang et al., 2020). In addition, several studies have shown that information is opaque in SOEs. SOEs are more likely to hire small auditors in the same region, where they leverage the small auditors' local knowledge for collusion and selective disclosure of information (Wang et al., 2008). Substantial evidence is that state ownership is associated with lower share price changes at the firm level (i.e., share price informativeness) (Hou et al., 2012; Ben-Nasr and Cosset, 2014; Tan et al., 2020).

2.2.2. State ownership and environmental performance

It has been argued that the government should address environmental and social concerns rather than firms because of its superior capability. Particularly, SOEs may be better equipped to deal with market failures and externalities resulting from these issues (Cazurra et al., 2014). Since SOEs serve as essential tools for governments to create social and public value, they have multiple purposes, missions, and objectives for their social responsibilities (Marquis and Qian, 2014). SOEs' political affiliation with the government facilitates their social and environmental responsibility assumption. SOEs who adhere diligently to state environmental protection policies will be eligible for government grants, subsidies, and tax incentives. This enables them to carry out the government's environmental policy conscientiously (Zhang, 2017). Therefore, SOEs actively address environmental issues, such as reducing emissions, developing eco-efficient products or services, conserving natural resources, and emitting less carbon dioxide (Hsu et al., 2023). Since the government appoints SOEs executives, they tend to align their investment, environmental, and development strategies with government standards (Zhang et al., 2019). Zhang et al. (2022) support this conclusion by demonstrating that entrepreneurial strategies motivate SOEs to take risks and promote green innovation.

Stock market responses to government environmental policies further substantiate SOEs' environmental responsibilities. Li et al. (2023) find that SOEs disclose more environmental information in compliance with government regulations than non-SOEs and exhibit a reduced risk of environmental incidents. Consequently, when the central government implements environmental oversight, the adverse effect on the market reaction of SOEs is less pronounced. A contrary viewpoint is presented by Guo et al. (2020). Their research suggests that SOEs are more likely to proactively respond to government directives when introducing stringent environmental regulations, thereby encountering more significant risks. Investors prioritising environmental concerns may perceive the new policy as detrimental to SOEs, resulting in a more significant and negative market reaction. Additionally, there is evidence that market-based environmental regulations can reduce pollution within SOEs. Tang et al. (2024) show that after enrolling in environmental pollution liability insurance, SOEs achieved a 12.83% reduction in emissions, whereas non-SOEs only achieved a 9.34% reduction. The superior environmental practices of SOEs result in higher social responsibility scores than their privatised counterparts (Boubakri et al., 2019), and institutional investors prefer to allocate assets to SOEs (Li and Lu, 2016).

However, state ownership may deter SOEs from adopting environmental management practices. Research indicates that SOEs have a greater bargaining power than non-SOEs when negotiating environmental enforcement with local environmental protection authorities (Andersson et al., 2018). SOEs evade environmental regulations by combining central protectionism with weak oversight from environmental bureaucracies. Eaton and Kostka (2017) state that central SOEs are responsible for many severe environmental pollution incidents and regularly violate environmental regulations and guidelines. Jiang et al. (2014) investigate factors associated with industrial pollution intensity using a firm-level dataset covering over 100 Chinese cities. The study has revealed that political connections undermine the enforcement of environmental regulations, resulting in increased pollution emissions from SOEs. Liang and Langbein (2021) find that provinces with a dominant state-owned economy exhibit lower SO2 emissions during an SO2 control campaign. However, this effect is insignificant in provinces with more anti-corruption case investigations. There may be rent-seeking activities between SOEs and government officials, enabling SOEs to evade their pollution reduction responsibilities. The central government employs environmental inspections to prevent collusion between local governments and SOEs. However, these inspections only temporarily reduce SOE emissions, as the SOEs return to their previous emission levels after completing the inspection (Karplus and Wu, 2023).

As a concession for political or economic reasons, SOEs pay significantly lower environmental taxes than non-SOEs (Maung et al., 2016). Such concessions are especially prevalent in economically underdeveloped provinces that depend heavily on SOEs for economic growth. As a result, SOEs can avoid paying their fair share of pollution control fees and cannot reduce their emissions. Wang and Zhang (2020) also indicate that SOEs receive more government resources and are less concerned about their long-term survival, thus resulting in a limited incentive for them to increase their environmental expenditures to attract state subsidies. With political influence and robust state support, SOEs face less scrutiny from regulators and display limited engagement in environmentally responsible activities to gain societal trust (Shahab et al., 2023). Li et al. (2013) highlight that state ownership does not necessarily lead to increased sustainability disclosure. Instead, SOEs may be exempt from communicating with government stakeholders due to their inherent political legitimacy, resulting in lower sustainability information disclosure, particularly regarding CSR disclosure (Marquis and Qian, 2014). Therefore, the political connections and misallocation of resources between SOEs and the government contribute to the persisting unsatisfactory performance in reducing emissions among SOEs despite increasingly stringent pollution control regulations (Xiao and Shen, 2022).

2.2.3. The administrative hierarchy and SOEs' environmental performance

States are not monolithic entities. The central and local governments often have divergent priorities in many political systems (Xiao and Zhu, 2022). As a large and complex transitional economy, China has a hierarchical and autonomous relationship between the central and local governments (Marquis and Qian, 2014). The central government has adopted more balanced and long-term approaches to economic and social development rather than focusing exclusively on the growth of the economy (Wang et al., 2018). Local governments are responsible for implementing the central government's policies and achieving its strategic goals when a political system is characterised by central control and command (van der Kamp, 2021). However, some governments still prioritise GDP growth because it can increase tax revenues, promote economic development, and promote local officials' cadres (Wu and Cao, 2021). The contradictory relationship between the central and local governments can also be observed in the environmental performance of the central and local SOEs (Luo et al., 2016).

Liang and Ma (2020) find that central SOEs successfully met the government's binding energy-saving targets in China's Thousand Enterprises Energy Saving Plan. Furthermore, central SOEs reduced their energy consumption by 31.68% compared to their local counterparts. Dong et al. (2022) support these findings, demonstrating that central SOEs align their political goals with those of the central government and actively engage in carbon reduction activities. Despite this, local SOEs are less willing to participate in carbon reduction activities due to a lack of regulation and administrative proximity to the central government. Luo et al. (2016) develop a corporate social responsibility (CSR) disclosure framework to address the institutional complexity caused by conflicting requirements between central and provincial governments. Their findings indicate that SOEs subject to central policy regulation tend to publish lower-quality CSR reports in provinces where GDP growth is highly valued. Conversely, SOEs with close ties to the central government tend to publish reports promptly and at a higher level of quality.

Furthermore, previous studies have indicated that local SOEs are less inclined to innovate than central SOEs due to their profit-oriented nature (Yu et al., 2022). Those central SOEs expected to align with the central government's strategy display a greater interest in innovation, particularly in the environment (Zhang et al., 2019). Wang and Zhang (2020) examine the relationship between state subsidies and corporate environmental expenditure. State subsidies have a more pronounced impact on the environmental expenditures of central SOEs. As representatives of the nation's image, these enterprises are subject to greater scrutiny and supervision when fulfilling their environmental responsibilities. This leads central SOEs to increase their investments to demonstrate their commitment to resolving pollution issues (Marquis and Qian, 2014). The central state has made efforts to reduce collusion between local governments and local SOEs through environmental reforms. For example, Han and Tian (2022) report that China's environmental vertical reforms have centralised the enforcement power at the highest levels, preventing local governments from shielding SOEs. As a result, these reforms have enhanced the environmental performance of local SOEs.

2.3. Market-driven instruments to green transformation

The section reviews research on market-driven instruments for promoting green transformation, including green finance, ESG practices, and voluntary corporate certification. Specifically, the dissertation examines whether market-driven instruments facilitate corporate green transformation and generate positive firm value. Firstly, the dissertation examines how green finance contributes to improving the environment. Studies emphasize that credit constraints encourage firms to adopt green technologies to reduce pollution emissions. It can enhance corporate environmental performance and reward firms for adopting environmentally friendly practices through green finance. However, some firms may misuse green finance for greenwashing. Secondly, the dissertation reviews the benefits of corporate ESG practices for both firms and stakeholders. These benefits include enhancing firm value, improving financial performance, and mitigating the risk of collapse. However, certain ESG practices like greenwashing fail to improve environmental performance genuinely. Finally, the dissertation reviews the positive environmental initiatives firms undertake through third-party certification. This approach has yielded favourable economic and environmental outcomes. It is, therefore, crucial to examine whether voluntary actions can increase firm profits and reduce pollution, thus facilitating the process of green transformation.

2.3.1. Green finance with corporate economic and environmental performance

Green finance serves as an effective supplementary mechanism in administration by internalizing the potential adverse costs of environmental fines into the marginal costs of borrowing for firms (Huang et al., 2023). According to the Porter hypothesis (Porter, 1991), green finance enables firms to comply with reasonable environmental regulations, thereby encouraging traditional businesses to recognize the "green attributes" of their business activities (Dagestani et al., 2023). This recognition stimulates the development of green technologies, facilitates ecological transformation and technological advancement, and thus allows firms to achieve high-quality development while reducing carbon emissions (Hu et al., 2021; Neagu et al., 2024). According to Fan et al. (2021), banks' preferential treatment toward green loans motivated large firms to invest in emission-reduction facilities and rapidly upgrade pollution-free clean technologies, allowing them to access the green loan market and lower their carbon intensity. Smaller non-compliant firms were forced to scale back production due to reduced loans and higher costs.

Furthermore, Hu et al. (2021) observe that green finance imposes strict credit constraints on highly polluting firms, increases their financing costs. These compel them to adopt green technologies for cost-effective environmental compliance, enhancing their competitive advantage and social reputation. Neagu et al. (2024) find that firms can use green loans to upgrade their technology and reduce carbon emissions. This action can diminish energy and utility costs and minimizing the risk of corporate debt defaults. Based on Degryse et al. (2023), green banks reward environmentally friendly firms by offering more affordable green loans following the Paris Agreement. Consequently, green firms enjoy loan terms approximately 50 to 59 basis points better than their brown counterparts. Research also indicates that green finance has increased public awareness of environmental concerns, causing industries that contribute significantly to air pollution to face social pressure to improve their environmental performance (Gu et al., 2023).

As a form of green finance, green bond is viewed as an effective financing instrument for transitioning to a green economy (Monasterolo and Raberto, 2018). Flammer (2021) proposes a conceptual framework for understanding how green bonds affect firms based on signalling, greenwashing, and capital cost theories. Signalling theory asserts that green bond issuance demonstrates a credible environmental commitment. Greenwashing theory suggests that the issuance of green bonds may create the appearance of environmental responsibility without taking any concrete action. Corporate green bonds will not improve environmental performance if greenwashing prevails. Green bonds are argued to be more cost-effective than conventional bonds due to their lower capital costs. It has been shown that green bonds can attract investors willing to pay a premium over their non-green counterparts (Nanayakkara and Colombage, 2019; Zerbib, 2019). However, Larcker and Watts (2020) find that green bonds do not provide higher returns to attract more investors. Additionally, firms issuing green bonds may not always enjoy lower financing costs.

Research has limited evidence that issuing green bonds improves firms' environmental and non-environmental performance. The issuance of green bonds has also been associated with increased stock prices, improved financial ratings, and enhanced financial performance, resulting in shareholder benefits (Tang and Zhang, 2020; Zhang et al., 2021). As a financial instrument that promises positive environmental benefits, some studies have begun to focus on whether green bonds are greenwashing. Evidence shows that banks that issue green bonds reduce lending to industries with high carbon emissions (Cao et al., 2021). Flammer (2021) finds that firms issuing green bonds experienced substantial improvements in environmental performance, leading to reduced carbon dioxide emissions. However, some studies have found that green bonds are being greenwashed. Leung et al. (2022) point out that companies only reap the low cost of capital associated with the issuance of green bond without taking tangible steps to decrease carbon emissions, which is inconsistent with the initiative to issue green bonds. Tuhkanen and Vulturius (2020) find a disconnect between issuers' climate goals and their green bond framework and several areas for improvement in issuers' post-issuance reporting. Green bond issuers have little pressure to use their proceeds to meet ambitious science-based goals.

2.3.2. ESG practice with corporate economic and environmental performance

Several studies demonstrate a positive correlation between a company's ESG ratings/activities and firm values or financial performance. Pástor et al. (2021) propose an equilibrium model and demonstrate that investors prefer to pay an excellent price for firms that adhere to environmental and social standards, which reduces the company's capital cost. Investors are reluctant to hold brown stocks due to climate change risks. This conclusion is supported by Hong and Kacperczyk (2009), who examined the ownership, valuation, and return differences of "sin" stocks, including those associated with the alcohol, tobacco, or gaming industries. These so-called sin stocks, characterized by low ESG scores, exhibit lower valuation ratios. A segment pricing effect results from confident investors' avoidance of sin stocks due to social norms. Through a comprehensive textual analysis, Krüger (2015) examines sustainability practices' positive and negative effects on the US stock market. The findings revealed that negative ESG practices elicited a strong adverse market reaction due to their inclusion of extensive legal and quantitative information. Therefore, unsustainable corporate behaviour places a significant financial burden on shareholders. Alessi et al. (2021) employ a linear factor model to investigate the role of greenness and environmental transparency. Investors' preference for green investments leads them to accept lower returns if they invest in greener, more transparent stocks. Zhang (2022) conducts a study on global stock markets and discovered that investors are highly responsive to climate-related risks. As concerns regarding these risks intensify, companies with higher ESG scores generally exhibit higher stock returns than others.

Corporate ESG activities have been extensively researched regarding their impact on financial performance. Borghesi et al. (2014) find that companies with superior ESG performance generate greater free cash flow. Gao and Zhang (2015) identify a positive correlation between higher ESG performance, concurrent earnings-return relationships, and a higher Tobin's Q value. Albuquerque et al. (2019) find that corporate ESG activities can stimulate investment in differentiated products, enabling companies to benefit from higher profit margins. Dhaliwal et al. (2011) observe that companies with outstanding social responsibility performance experience lower equity capital costs. In addition, these companies attract specialized institutional investors and analysts. With access to comprehensive ESG information, analysts are able to lower absolute forecast errors and reduce dispersion. Flammer (2015) highlights that implementing proposals closely aligned with ESG leads to positive announcement returns and superior accounting performance.

Previous studies also highlight other benefits of firm ESG practices. For example, Kim et al. (2014) demonstrate that companies with CSR practices are less likely to conceal negative news, mitigating stock price collapse risks.. Lins et al. (2017) observe that companies with superior ESG performance were less susceptible to shocks during the 2008-2009 financial crisis. This study implies that ESG is a protective measure, bolstering corporate financial resilience. Seltzer et al. (2022) present evidence linking companies' ESG scores and climate regulatory risk to their bond credit ratings. Credit ratings and yield spreads tend to be lower for companies with poor environmental performance, particularly in states with strict environmental regulations. Stellner et al. (2015) reveal that companies enjoy higher credit ratings if their countries prioritize ESG issues.

Although ESG activities can benefit firms and stakeholders, some dubious ESG practices include greenwashing, ESG wash and ESG divergence. As ESG activities may be costly, some firms may choose greenwashing by selectively disclosing their ESG activities or decoupling symbolic talk from genuine action (Ramus and Montiel, 2005). Public statements concerning a company's commitment to society may mitigate its stock market risks, suggesting that investors have indeed been influenced by cheap talk (Bansal and Clelland, 2004). Symbolic ESG disclosures may be used to meet government requirements (Berrone et al., 2017). Firms may also wash ESG by strategically allocating resources to various ESG dimensions. Khan et al. (2016) show that firms whose ESG scores increase materially outperform those whose scores increase non-materially. Serafeim and Yoon (2022) demonstrate that investors are more interested in material ESG news than non-material ESG events. Companies may use limited resources to maximize their benefits by selectively implementing ESG practices, also known as ESG washing, to maximize their benefits.

2.3.3. Corporate certification with corporate economic and environmental performance

Addressing climate change will require the market to create economically and ecologically products and services, often supported through voluntary certification standards (York et al., 2018). For example, the construction sector uses the Building Environmental Assessment Method (BEAM) Plus and Leadership in Energy and Environmental Design (LEED) voluntary certification standards to reduce negative environmental effects by simulating green building growth (Kahn and Kok, 2014; Chegut et al., 2016; Eichholtz et al., 2019). Research documents that BEAM Plus and LEED are valuable. This voluntary certification can positively impact a building's financial performance (Fuerst and McAllister, 2011; Brounen and Kok, 2011; Kahn and Kok, 2014; Chegut et al., 2016). For example, Eichholtz et al. (2010) document that obtaining LEED or Energy Star certification significantly benefits the office buildings' rent and selling price. It is estimated that the average rent increase for certified office buildings is approximately 2%, while the actual rent increase is approximately 6%. In addition, certified buildings command a premium of 16% over non-certified buildings. Evidence shows that homes with green certifications trade at higher prices and command higher rental rates than homes without green certifications (Kahn and Kok, 2014; Chegut et al., 2016). Additionally, mortgage spreads for certified buildings are significantly lower than conventional ones (Eichholtz et al., 2019). This can be attributed to the green price premium, reducing the risk of defaulting on loans (An and Pivo, 2020). Further, Eichholtz et al. (2012) find that real estate investment trusts (REITs) with more environmentally certified buildings exhibit superior operating performance. These REITs demonstrate higher returns on assets, returns on equity, operating income, and cash flows. The solid financial performance of REITs leads to reduced exposure to systematic risks.

Certifications such as ISO and ELC for environmental labelling have been found to augment product sales, facilitate market entry, confer cost and differentiation advantages to firms, and contribute to overall profitability (Wang et al., 2015; Goedhuys and Sleuwaegen, 2016; Zhou et al., 2023). According to Jong et al. (2014), ISO 14001 certification enhances a company's resource portfolio and capabilities, contributing to short- and long-term financial performance. Sales growth drives long-term improvements in return on assets (ROA). Elfenbein et al. (2015) reveal that certification enhances market performance by providing valuable information, enabling buyers to evaluate seller quality, and linking willingness to pay with quality levels. This fosters faster growth for high-quality entrants and increases market competitiveness. Marinovic et al. (2018) suggest that companies invest in quality and bolster their reputation at lower certification costs to ensure product credibility and increase revenue. Bonetti and Ormazabal (2023) investigate the economic ramifications of corporate governance practice certification. Companies with good governance received positive market responses, attracting foreign investors and fostering performance growth. In addition to economic benefits, certification also plays a crucial role in enhancing firms' legitimacy. Specifically, certification confers reputational benefits and boosts stakeholders' confidence in the firm's prospects in countries with weak institutions (Li et al., 2018; Lamin and Livanis, 2020). Moreover, foreign firms that obtain certification experience increased legitimacy when operating in emerging economies (Zhang et al., 2019).

Moreover, third-party certification goes beyond economic and reputational benefits by generating environmental advantages. Research has shown that it can prevent corporate greenwashing and incentivize firms to adopt better technologies aimed at reducing carbon emissions and pollutant production (Arimura et al., 2008; Arocena et al., 2021; Ferrón-Vílchez, 2016). According to He and Shen (2019), third-party certification improves resource utilization efficiency and resource allocation within Chinese listed firms. These facilitate the development of green technology, leading to environmental pollution reduction. Potoski and Prakash (2005) find that facilities with ISO 14001 certification exhibited more significant pollution emissions reductions than those without certification. Specifically, factories with ISO 14001 certification achieved a 9% reduction in pollutant emissions (Barla, 2007). Arimura et al. (2011) show that third-party certification has a spillover effect that improves suppliers' environmental performance. ISO certification enables companies to enforce specific environmental measures within their supply chains, thus encouraging suppliers to enhance the environmental performance. This conclusion is in accordance with Simcoe and Toffel (2014), who revealed that government green procurement stimulates the private sector to adopt LEED standards, reduce building carbon emissions, and improve overall environmental performance.

2.4. The research framework

Section 2.1 reviews the impact of the traditional command-and-control approach on environmental governance. Previous studies highlight that the central government delegates environmental governance objectives to local governments, employing administrative measures to reduce pollution emissions. However, local governments often hesitate to sacrifice economic development to implement centrally determined transformation policies, resulting in the transfer and sheltering of pollution between regions. The central government has recognized these malpractices and incorporated environmental performance into the target responsibility assessment of local officials. Local officials are more likely to reduce pollution when pollution reduction targets are tied to cadre promotions. However, economic development remains the preferred strategy for promotion. Local governments often compromise environmental goals to meet promotion requirements. Accordingly, it remains unclear whether China's top-down system effectively enforces local green transition. Meanwhile, the target responsibility contract effectively reduces pollutant emissions but not carbon emissions. Without specific incentives and penalties for carbon reduction, it remains uncertain whether local governments can effectively respond to carbon reduction policies under the traditional control and command approach. Green economies require simultaneous pollution and carbon emissions reduction. Chapter 3 will investigate whether the target responsibility system can effectively promote local green carbon reduction practices, addressing existing research gaps.

Section 2.2 how state ownership contributes to under the existing pressure-based system. State ownership links the government to the market, allowing the state to influence firms via ownership to shape market behaviour. Studies find that SOEs exhibit unique financial characteristics due to easy access to resources such as credit and government subsidies, which may distort investment efficiency and cause negative financial outcomes. The environmental performance of SOEs remains contentious. Political connections obligate SOEs to adopt the government's environmental governance mandates and to promote environmental responsibility through performance contracts with their CEOs. However, these political ties may also lead the government to shield SOEs from engaging in environmentally detrimental behaviours, particularly if the central government cannot effectively monitor local governments' implementation of environmental policies. As incentives to promote economic development intensify, local governments more distant from the central government may collude with SOEs to evade environmental regulations, thereby increasing pollution emissions. A green economy requires shifting to a low-carbon, environmentally friendly, and sustainable development model, leading governments to pressure SOEs to meet this goal. Due to the uncertainty surrounding SOEs' environmental performance, the government's call for a green economy transition remains uncertain. It is unclear whether these enterprises will genuinely intensify their decarbonization efforts or if their financial performance will suffer due to their obligations to reduce carbon emissions. Therefore, Chapter 4 will examine whether and how state ownership can fulfil its responsibility for green transformation to address this research gap.

Traditional top-down approaches often overlook the market. Generally, companies are more receptive to voluntary actions than mandatory administrative measures or economic instruments such as emissions taxes. Market-driven voluntary actions by firms yield financial benefits and reduce the implementation burden on governments. Section 2.3 investigates market-based instruments, including green finance and corporate ESG practices, which can enhance financial and environmental performance. Despite this potential, research indicates that a single market-based instrument may not contribute to improved environmental performance. Several studies have revealed that firms misuse green finance by investing in brownfield projects and strategically employing ESG practices, such as greenwashing, to make misleading environmental claims. Greenwashing can obscure actual environmental damage and mislead markets and regulators about a company's environmental performance. As a result, it remains uncertain whether market-driven instruments effectively reduce carbon emissions and enhance corporate performance. An independent third-party certification is necessary to enhance the effectiveness of market-based instruments. Research has shown that voluntary certification by companies can result in genuine environmental improvements. However, there is limited empirical evidence regarding the impacts and benefits of third-party certification on green finance and ESG practices. This research gap will be filled in Chapter 5 by investigating whether market-driven instruments can simultaneously positively affect corporate green transformation.

Figure 2.1 presents the research framework for the dissertation, outlining the path towards green transformation in China. The subsequent three chapters will validate this framework. Chapter 3 evaluates the effectiveness of the government's target responsibility policy in promoting regional green development. Chapter 4 examines whether state-owned firms can assume responsibility for green transformation, and Chapter 5 investigates how the market mechanism can facilitate corporate green transformation. The dissertation identifies the impact of public policy, state ownership and market mechanisms on the transition to a green economy.

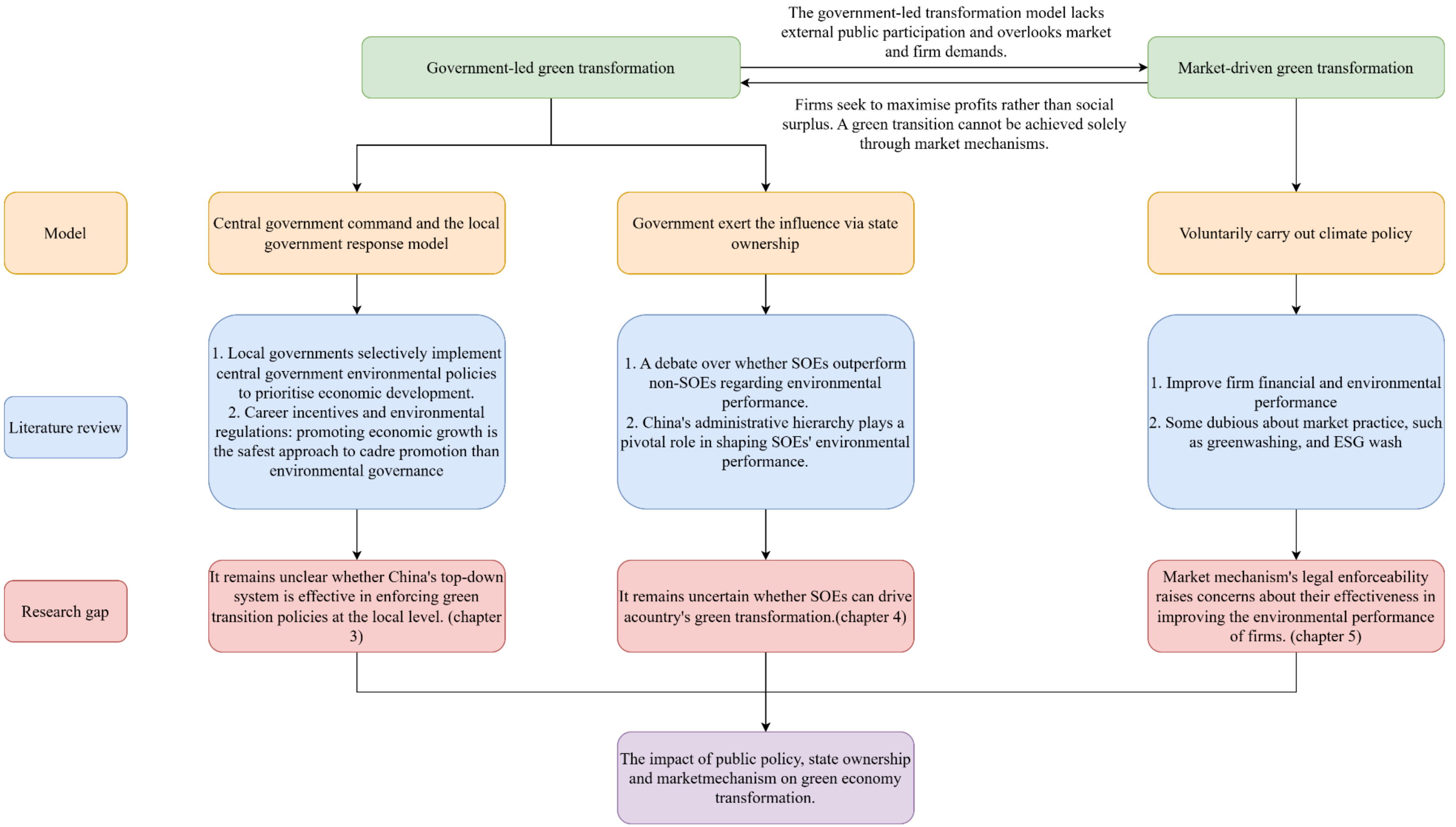

Figure 2.1 Research framework

This figure provides the research framework of the dissertation.

Chapter 3. Promoting Local Green Practices through Target Responsibility System

3.1. Introduction

This chapter investigates whether promoting local green practices through the target responsibility system can facilitate local green transformation. Local climate governance is crucial for local green transition, which involves different stakeholders and complex relationships, such as central versus local governments and public versus private sectors (Newell et al., 2012; Emelianoff, 2014; Boyd and Juhola, 2015). Local governments around the world have actively engaged in climate initiatives and efforts to reduce greenhouse gas emissions (Castán Broto, 2017; Hughes et al., 2020). Despite increasing commitment, local governments' actions remain superficial (Yazar and York, 2023). Effective climate programmes require adaptive and innovative governance, such as integrating climate policies into existing bureaucratic structures (Aylett, 2013). However, the potential of bureaucratically rooted urban climate governance innovations to achieve the local green transformation remains uncertain.

Politics can significantly reshape green policies and transform consumption and production patterns (Besley and Persson, 2023). China is an ideal country to explore whether and how political forces can influence green transition, as the central government in China frequently uses political forces to solve social and environmental problems[1]. The central government delegates most of its responsibility for public

[1] Several studies have evaluated the effectiveness of political force in address social issues, such as poverty reduction. For example, Zhong et al. (2024) show that China's East-West poverty alleviation collaboration policies significantly enhanced e-commerce trade between twinned cities. Furthermore, multifaceted poverty reduction policies have been shown to increase the income of beneficiary families (Li et al., 2023). Environmental governance initiatives, directed by the central government and executed by local authorities, have achieved substantial progress over recent decades. Previous studies suggest that China's water quality regulation program has decreased pollution-intensive activities in regulated areas (Chen et al., 2018). A nationwide real-time air quality monitoring and disclosure program resulted in a 40% reduction in PM2.5 (Greenstone et al., 2021). However, local leaders' motivation to curtail polluting activities remains weak, as downstream neighbours bear the social costs (Kahn et al., 2015; He et al., 2020).

services (e.g., environmental governance) to local governments (Kostka and Nahm, 2017) and explicitly incorporates quantitative ambient environmental quality targets in the performance appraisal and promotion of local government officials (Du and Yi, 2022; Lin et al., 2024). As opposed to the mandatory inclusion of pollution reduction targets into the local government target responsibility system, China's carbon reduction policy operates voluntarily under the central government's guidance (Khanna et al., 2014). This policy framework grants local governments greater enforcement power (Chen et al., 2022). Despite aiming to alter organizational behaviour, the legal enforceability of voluntary policies is questionable due to the lack of incentives and binding obligations (Zhang et al., 2024). Therefore, it is questionable whether such voluntary programs can promote local governments' green practice.

The Chinese central government initiated the Green Building Action Programme in 2013, which aims to reduce energy consumption and minimize carbon footprints in buildings. This programme employs a centralized approach, wherein the central government delineates policy frameworks and allocates implementation targets to subordinate local governments. The central government integrated green building targets into performance evaluation metrics of local officials to encourage proactive engagement with sustainable development challenges among provincial leaders. However, contrasting with prior centralized mandates in environmental protection[2], local governments (prefectural level or below) have discretionary power in formulating green building targets and deciding whether to adopt a target responsibility system. The central government only provides general guidance and non-mandatory recommendations, which grants local governments considerable flexibility in implementation. This discretion introduces potential variability in policy efficacy. Consequently, there is a question as to whether integrating green building targets into the target responsibility system of the local government can effectively stimulate local enthusiasm for the green practices.

[2] Previous studies indicate that this performance evaluation system, characteristic of the Chinese governance model, effectively incentivizes local officials to prioritize emission reductions by correlating their career prospects with their jurisdiction's environmental performance (Zheng et al., 2014; Chen et al., 2018; He et al., 2020; Wu and Cao, 2021).

To examine the impact of voluntarily incorporating green building targets into the target responsibility system on implementing green building practices, this study compiles a comprehensive dataset that combines socioeconomic, green building, and land transfer data. Data is exhaustively gathered from 216 prefecture-level cities, 195 of which enacted green building action plans per the instructions of the central and provincial governments, and 21 cities refrain from issuing such plans. Among the 195 cities with action plans, 112 adhere to central government mandates to integrate green building targets into target responsibility systems. From 2008 to 2020, these cities collectively amass 9,336 certified green buildings. To accurately evaluate the impact of green building target responsibility assessments, this study correlates certified green buildings with land transfer data to identify whether the land parcel is used to construct a green building project and employs a DID identification strategy. This study uses a propensity score matching (PSM) approach to estimate an appropriate policy year for cities that have not issued green building action plans.

Preliminary empirical analysis indicates that integrating green building targets into the performance evaluation metrics of local government significantly spurs the development of certified green buildings. Cities that have adopted the target responsibility system report a more significant proliferation of certified green buildings than those that do not. Subsequent analyses examine the heterogeneous effects of the target responsibility system on green building development by considering both developer characteristics and performance assessment methods. Integrating green building targets into the target responsibility system substantially increased the number of green government buildings, yet the private sector's response was less pronounced. The target responsibility for green buildings can be assessed in two ways, either through the local government's energy-saving target responsibility system or through the cadre promotion metric. The findings suggest that the latter is more effective at fostering green building development. Further analysis suggests that incorporating green building development into the target responsibility system improves the quality of green buildings and incentivizes the construction of higher-rated green buildings; however, the increase in green buildings is primarily observed in public buildings, with less impact on commercial and residential buildings.

The findings underwent rigorous validation through a series of normative tests, including verifying the parallel trends assumption between control and treatment groups, placebo tests to eliminate the influence of unobserved variables, and excluding confounding effects from low-carbon pilot city policies. In addition, this study excludes provincial capitals and sub-provincial cities to reconstruct research sample. This study also aggregates the certified green buildings from the land level to the city level to examine the impact of the green building target responsibility system.

This study demonstrates a causal relationship between integrating green building targets into the target responsibility system and the growth of urban green buildings. This study further elucidates the mechanisms underlying this effect. This study analyses government annual work reports spanning 2007 to 2020, focusing on the disclosure of local government's efforts to mitigate carbon footprints and pollution. This study finds that incorporating green building targets into local governments' target responsibility system would heighten governmental environmental concerns, catalysing more green initiatives. Moreover, governments actively disseminate information regarding green building policies and regulations to promote development locally, increase public awareness of green building principles, and increase the demand for green buildings. Additionally, local governments would augment financial incentives to support green building development, which could also help boost the construction of green buildings. Further analysis investigates the impact of the green building target responsibility system on urban carbon intensity. The empirical results show that the green building target responsibility system significantly reduces urban carbon emissions.

This study is not the first to empirically explore the relationship between environmental performance and the local government target responsibility system in the Chinese context. Previous studies have examined the impact of mandatorily integrating environmental performance into the cadre evaluation system on pollutant emission reduction. For example, under the two-control-zone policy, the central government includes the sulphur dioxide emission quota in the performance evaluation of mayors and municipal party secretaries. This prompts local officials to take effective measures to reduce SO2 emissions (Chen et al., 2018). This paper is distinguished by its focus on how local governments can effectively implement carbon reduction policies through voluntary targeted responsibility actions. In pollution abatement governance, prolonged exposure to air pollution diminishes citizens' satisfaction and trust in local government performance (Alkon and Wang, 2018). Lower political trust reduces local officials' chance of being promoted, motivating them to mitigate air pollution (Yao et al., 2022). In contrast, carbon emission reduction is primarily a guiding concept without specific targets (Zhang et al., 2024). Local governments and the general public do not comprehensively understand low-carbon development. While air pollution has immediate and perceptible health effects, carbon dioxide emissions have long-term and irreversible effects on climate change and the environment (Solomon et al., 2009). Consequently, the public cannot perceive the government's carbon reduction efforts directly. This study investigates whether the voluntary target responsibility system can effectively promote local carbon emission reduction practices amid weak incentives and constraints. Evidence suggests that voluntary target responsibility contracts signed by local governments can effectively promote green building practices and reduce urban carbon footprints.

The remainder of this chapter is organised as follows. In Section 3.2 discusses the institutional background and review the literature and development of the research hypothesis. Section 3.3 contains proposed empirical strategy and descriptions of the data and variables. Section 3.4 presents empirical results. Section 3.5 concludes this chapter.

3.2. Institutional background, literature review and hypothesis development

3.2.1. Institutional background

As a pillar industry in China, the real estate and construction sectors contribute 30% to the nation's carbon dioxide emissions (Lu et al., 2016). The central government has proposed green building as an important measure to achieve energy-saving and emission-reduction goals and pursue low-carbon and green development. As a result, the central government issued the National Green Building Action Plan in 2013. The plan clearly defined the goal of green building development during the "12th Five-Year Plan". By the end of 2015, 1 billion square meters of green buildings will have been constructed, as well as ensuring that 20% of new urban buildings meet green building standards. Local governments have introduced local action plans in response to central government directives. Local governments have incorporated green building targets into their energy-saving target responsibility system to encourage the adoption of green buildings. Green building development has even been incorporated into the performance evaluation metrics of local officials.

Many countries have formulated green building standards and evaluation systems to encourage green building practices, such as the LEED and the BEAM Plus green building evaluation system. These systems have significantly stimulated green building development (Kahn and Kok, 2014; Chegut et al., 2016; Eichholtz et al., 2019). In 2008, China officially implemented its own green building evaluation system. The system comprises five indices: safety and durability, health and comfort, occupant convenience, resource conservation, and environmental livability. Each category includes both prerequisite items and scoring items. Green buildings in China are classified into three levels: one-star, two-star and three-star, with three-star being the highest. Buildings can achieve these ratings by reaching 50, 60, and 80, respectively. Green building labels are divided into design labels and operation labels. A design label is awarded after the construction drawings have been reviewed and approved, while an operation label is awarded once the building has been in operation for one year. The design label assessment process includes reviewing design documents, approval files, and inspection reports. The operation label requires additional review of control documents during construction, on-site inspection reports after operation, and on-site verification. The design certification is valid for two years, whereas the operational certification is valid for three years. To further incentivize firms to engage in green building construction, the central government has proposed a financial rewards program for buildings that meet the national green building standards of two stars or above. The specific incentive criteria are CNY45 per square meter for a two-star green building and CNY80 per square meter for a three-star green building.

As of 2022, nearly 14,000 construction projects in China have obtained green building labels. However, despite evidence that green building incentives can encourage firms to adopt green practices, higher costs associated with green buildings hinder widespread adoption. Green building is currently primarily a government-led initiative in China. The government currently organizes green building certification and voluntarily participates by firms. One-star green buildings constitute the majority of green buildings labelled. Additionally, there is a significant issue known as "green building on paper", where operation certification accounts for only 6% of total certifications. A discrepancy exists between the promotion and implementation of green buildings in China.

3.2.2. Literature review and hypothesis development

Environmental challenges significantly threaten China's long-term development. For example, persistent air pollution reduces life expectancy (Ebenstein et al., 2017), increases mortality rates (Bombardini and Li, 2020; He et al., 2020), and diminishes worker and factory productivity (Chang et al., 2019; Kahn and Li, 2019; Fu et al., 2021). Furthermore, large-scale economic activities emit substantial amounts of carbon dioxide, which elevates greenhouse gas concentrations and significantly impacts the global climate (Olivier et al., 2017). Recognizing the severity of environmental pollution, China's central government has shifted its development focus towards reducing pollution and mitigating climate change (Wu and Cao, 2021). To this end, the central government has implemented various policies to address environmental issues. These policies have been effective. For instance, Liu et al. (2021) document that air pollution control policies prompt firms to upgrade production technologies, reducing sulphur dioxide emissions by approximately 26%. Water pollution regulation policies also curtail pollution-intensive activities in heavily regulated areas (Chen et al., 2018; He et al., 2020). Additionally, low-carbon pilot policies have effectively reduced CO2 emissions and carbon intensity (Lo et al., 2020; Feng et al., 2021; Xu et al., 2022). In addition, the central government monitors the effectiveness of environmental policy implementation through mechanisms such as central environmental protection inspections (van der Kamp, 2021; Chen et al., 2021; Karplus and Wu, 2023). The centralization of environmental governance has reduced regional pollution by encouraging firms to decrease their dependence on resources and energy (Zhang et al., 2018).

However, stringent environmental regulatory policies may increase production costs for firms, prompting them to relocate to cities with weaker environmental regulations (Dean et al., 2009; Kahn and Mansur, 2013; Hering and Poncet, 2014). High regulatory costs can also undermine local economic growth (Zhang, 2017). Fiscal decentralisation and GDP growth assessments reduce local governments' motivation to protect the environment (Oi, 1992; Qian and Weingast, 1997). Consequently, inconsistencies between central and local development goals may lead to collusion between local governments and firms to evade central regulations (Fisman and Wang, 2010; Jia and Nie, 2017). There is substantial evidence that local regulators circumvent central guidelines widely. For example, local governments strategically locate highly polluting firms upwind from air monitoring stations (Ghanem and Zhang, 2014) and downstream from water quality monitoring stations (He et al., 2020). In addition, local governments provide refuge for polluting firms, shifting the cost of environmental remediation to downstream communities (Sigman, 2002; Banzhaf and Chupp, 2012; Cai et al., 2016). The turnover of local officials further exacerbates pollution emissions (Eaton and Kostka, 2014; Deng et al., 2019).

In response to local governments' non-compliance, the central government started integrating policy implementation into the local government target responsibility system. The effectiveness of target setting relies on proper incentive design (List and Sturm, 2006; Burgess et al., 2017; Fisman and Wang, 2017). Research indicates that incorporating environmental targets into local government performance appraisal systems can prioritise environmental protection on local policy agendas and alleviate tensions between economic development and the environment (Du and Yi, 2022). Chen et al. (2018) find that including sulphur dioxide emission quotas in the performance appraisal systems of senior local bureaucrats in cities within the two-control zone significantly reduced sulphur dioxide emissions. These senior bureaucrats are willing to sacrifice economic development when pollution emissions are linked to performance. Kahn et al. (2015) show that cross-jurisdictional water pollution has significantly decreased in China since new cadre promotion rules incentivise pollution reductions across administrative boundaries. Therefore, incorporating green targets into local government performance appraisals is crucial for the state to encourage local leaders to address sustainability concerns.

In the Green Building Action Plan, the central government employs the target responsibility system to encourage provincial governments to take action. Historically, the central government signed responsibility contracts with provinces that specified emission reduction targets, which were handed down to municipalities (Chen et al., 2018). However, the central government does not assign binding targets or specific tasks to local governments in the Green Building Action Plan. Local governments have greater flexibility to set their green targets as long as they align with the central plan. There have been significant differences in the effectiveness of policy implementation when local regulators are given discretion (Leaver, 2009; Sjöberg, 2016). For instance, Duflo et al. (2018) show that regulators aggressively use their discretion to conduct multiple inspections of the most polluting organizations to reduce emissions. Raff et al. (2022) observe that states with discretion to enforce the federal Clean Air Act were less likely to enforce the Act than Democrats, resulting in a decline in capital expenditures for air pollution abatement. Similarly, Zhang et al. (2024) indicate that Chinese local governments do not significantly reduce carbon emission intensity under a low-carbon pilot policy where they can design their plans. On the other hand, local governments with limited resources will selectively implement targets based on varying payoffs and costs (Wu and Cao, 2021). Air pollutant emissions are more observable and addressed by local governments than CO2 emissions and wastewater (Liang and Langbein, 2015). Therefore, research indicates that target responsibility contracts for pollutant reduction reduce pollutant emissions but do not reduce CO2 emissions since there are no clear rewards for responsiveness and no penalties for non-responsiveness (Chen et al., 2018). As a result of these observations, this study proposes the research hypothesis.

Hypothesis: the integration of green building targets into target responsibility assessments effectively promotes local green practice initiatives.

3.3. Data, variables and methodologies

3.3.1. Data, sample and variables

Green building certification data

It is necessary to gather data on green building certifications to evaluate the impact of voluntarily incorporating green building targets into the government target responsibility system on local green building practices. Green building certification in China consists of two stages. The Ministry of Housing and Urban-Rural Development published green building certification results from 2008 to 2015. In 2016, the certification system transitioned to a market-driven approach, allowing government-approved building science research institutes to publish certification results. Therefore, government websites and websites of government-approved research institutes serve as the primary data sources. This study also uses pkulaw.cn (*Beida fabao*) to identify and collect information on green building certification projects across various cities. This database has been an extensive repository of Chinese central and local laws, regulations, and guidelines since 1949. The data collection efforts encompass browsing the government websites of 31 provincial-level administrative regions, 333 prefecture-level administrative regions, websites of government-approved research institutes, and the pkulaw.cn. These results in the acquisition of 11,400 certified green buildings. However, due to data incompleteness, this study excludes nine provincial-level administrative regions, including Xinjiang, Inner Mongolia, Tibet, Ningxia, Qinghai, Gansu, Sichuan, Yunnan, and Hebei. Furthermore, as this research concentrates on the prefecture-level city, this research rules out four municipalities with higher administrative levels, including Shanghai, Beijing, Tianjin, and Chongqing. Ultimately, the dataset comprises 9,336 certified green buildings.

Figure 3.1 illustrates the geographical distribution of certified green buildings in China, starting in 2008, the inaugural year of green building certification. The figure highlights an uneven distribution of green building certification across the country. Most certified green buildings are in developed eastern provinces, such as Shandong, Jiangsu, and Guangdong. Conversely, economically underdeveloped central and western regions demonstrate fewer certified green buildings. Furthermore, at the city level, a similar pattern emerges. Green buildings are more prevalent in economically developed provincial capitals than in economically underdeveloped prefecture-level cities.

Figure 3.2 depicts the change in green building certifications from 2008 to 2020. In 2008, only 5 green buildings received certification. By 2020, this number had skyrocketed to 1,409, marking an increase of nearly 280 times. The figure illustrates a general upward trend in green building certifications, with a substantial surge beginning in 2014 and peaking in 2019.

Figure 3.3 showcases the distribution of certified green buildings based on different labels. The number of projects with green building design labels consistently increased, particularly from 2014 onwards, culminating in a peak in 2019. The progress of the operation certification projects has been sluggish, with only 455 projects obtaining operation certification. These projects account for a mere 4.87% of the total number of certified green buildings. However, a discernible disparity exists between developing green building design and operation labels. This disparity suggests that China has placed a greater emphasis on design labels while promoting green buildings, while operation labels have received comparatively less attention.

Figure 3.4 focuses on the distribution of certified green building grades. Two-star green buildings have increased significantly over the past few years, particularly in 2017 and 2019. In 2018, two-star green buildings surpassed one-star green buildings. Conversely, the number of one-star green buildings experienced rapid growth in 2016, reaching its peak in 2017 before declining. This trend indicates a progression in China's green buildings from lower to higher levels of certification. However, three-star green building projects have grown relatively slowly, with only 587 projects receiving this highest certification. These three-star projects account for only 6.29% of all certified green buildings. Comparatively, one-star and two-star projects account for 43.31% and 50.40% of the total. This distribution reveals a substantial presence of lower-grade green buildings in the overall development of green buildings, highlighting a dearth of high-quality and high-level structures.

Figure 3.1 The geographical distribution of green buildings

This figure displays the distribution of certified green buildings from 2008 to 2020, covering 18 provincial administrative regions with 216 cities.

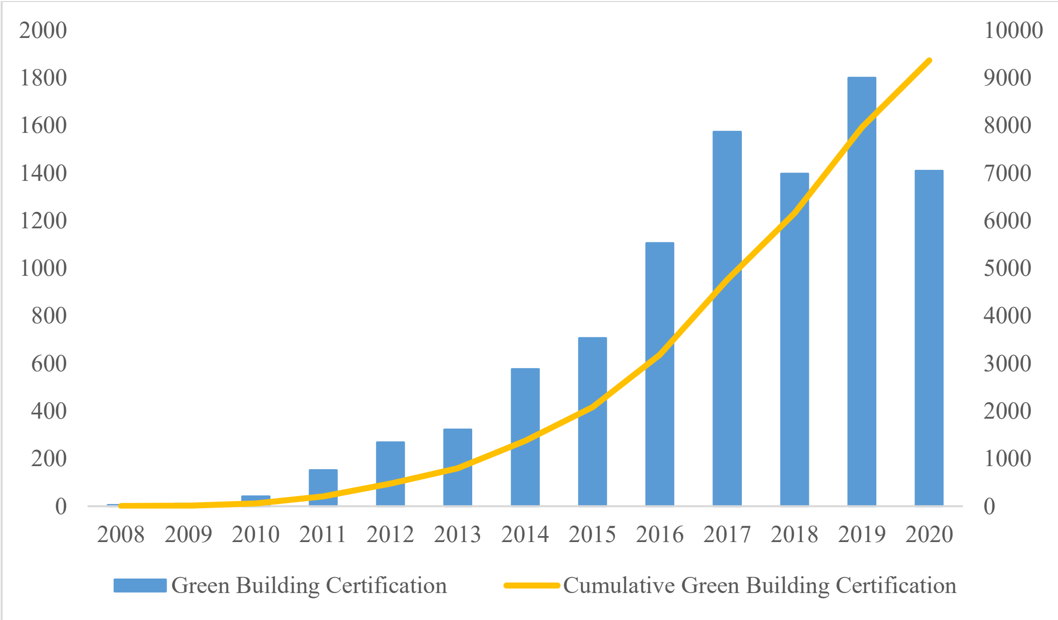

Figure 3.2 The number of certified green buildings

This figure shows the number of certified green buildings from 2008 to 2020, covering 18 provincial administrative regions with 216 cities.

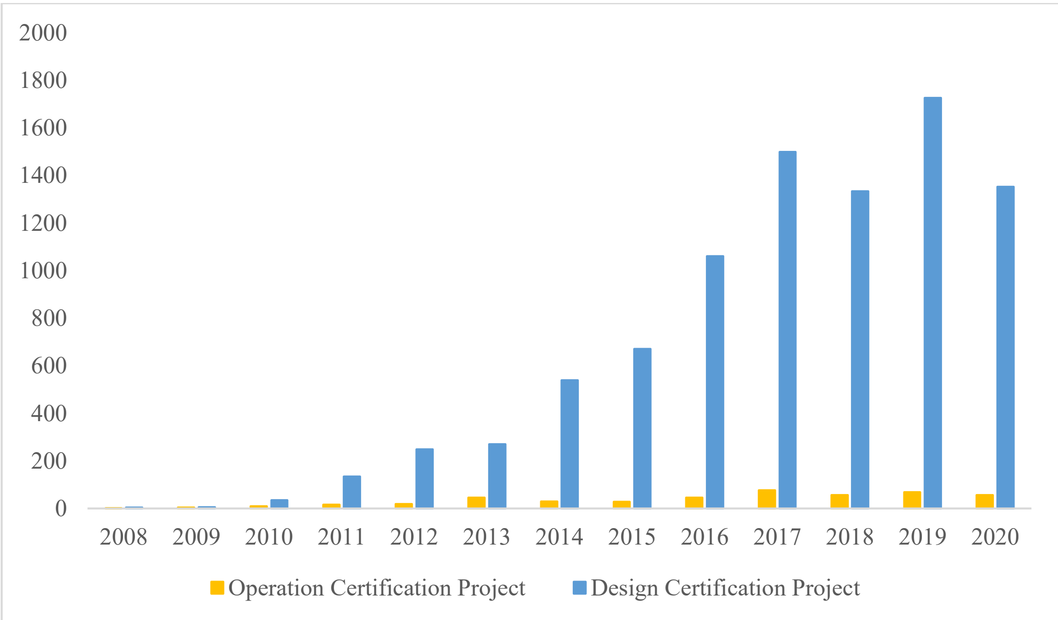

Figure 3.3 The number of operation and design certified green buildings

This figure demonstrates the number of operation and design certified green buildings from 2008 to 2020, covering 18 provincial administrative regions with 216 cities.

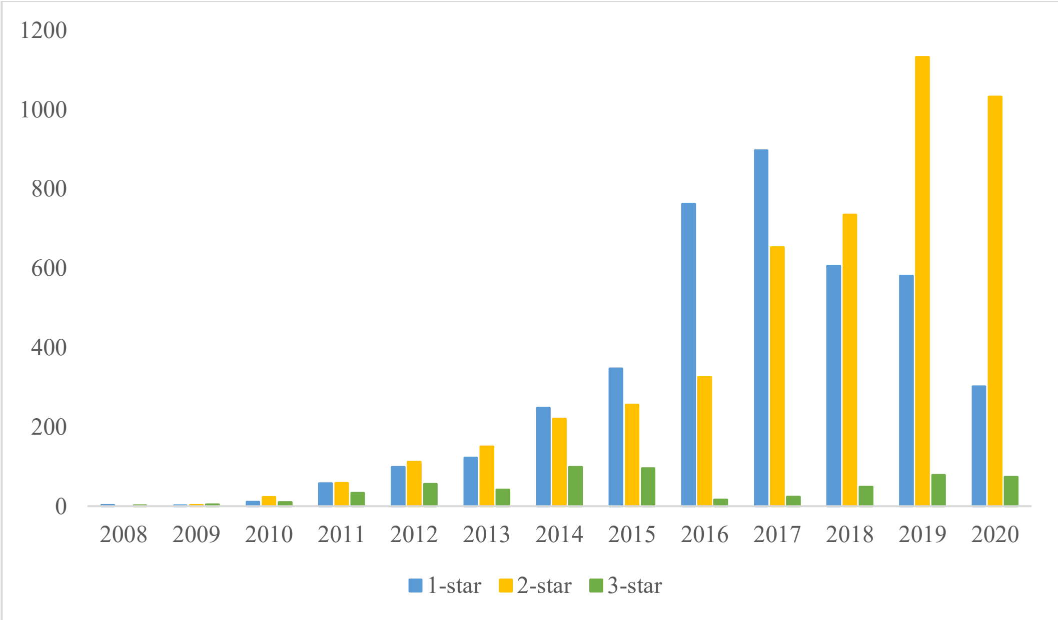

Figure 3.4 The number of certified green buildings ranking

This figure illustrates the number of certified green buildings by ranking from 2008 to 2020, covering 18 provincial administrative regions with 216 cities.

Green building target responsibility system data

This study examines whether voluntarily integrating green building targets into a target responsibility system can promote green building development. In 2013, China initiated a national green building action plan to encourage green construction. The initiative received a positive response from the local government. This study obtained policy documents on green building development from government websites and the pkulaw.cn. The regulations categorize local policy documents into three levels: local regulations, local government ordinances, and local normative documents. The analysis encompasses nearly 2,500 documents. It reveals that only a few provinces, such as Jiangsu, Zhejiang, and Liaoning, issue local regulations to promote green building development. Most regions focus on issuing local normative documents, such as the Green Building Action Plan, to foster green buildings. Studies indicate that lower-level governments may experience delays in issuing or implementing documents as bureaucratic control intensifies with central guidelines and may be less likely to reiterate the content of corresponding central guidelines (Boffa et al., 2016; Xiao and Zhu, 2022). Among the 18 provinces we examined, 195 cities formulated action plans to encourage green buildings in response to both the central and provincial governments' directives. However, 21 cities deviate from these instructions and do not issue green building action plans. Among the 195 cities that release action plans, 112 cities adhere to the central government's requirements by incorporating the promotion of green building development into the government's energy-saving target responsibility assessment or performance evaluation metrics of local officials, thereby reinforcing their accountability targets.

Table 3.1 Panel B reports summary statistics for green building assessment variables. The average local official promotion and non-promotion assessments are 0.12 and 0.33, respectively, and the average government energy-saving and non-energy-saving assessments are 0.24 and 0.21, respectively.

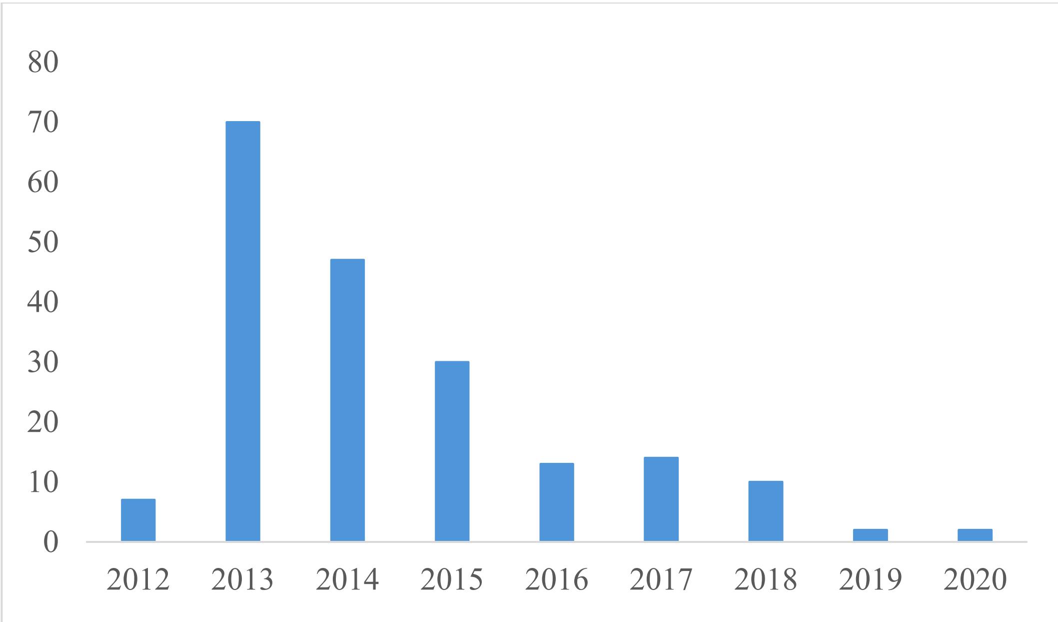

Figure 3.5 Number of cities implementing green building action plans over the years

This figure illustrates the number of cities implementing green building action plans from 2008 to 2020, covering 18 provincial administrative regions with 216 cities.

Land development project data

All urban lands in China are owned by governments. Land parcels from government land sale programs are the major source of land development. The *LandChina* database records detailed land transaction information from 2004 to 2024, encompassing over 2.3 million land transaction data across 333 municipal-level administrative districts.

The database includes information on land address, latitude and longitude coordinates, price, area, type, transfer method, usage term, owning company, city of transfer and transaction year. Due to the rarity of certified industrial green buildings, this study excludes industrial-related land based on land use type. Finally, research sample contains 645,952 land development projects.

To associate certified green buildings with specific plots, this study uses the Amap API to determine the longitude and latitude of each project based on its name and the corresponding city. This study conducts manual searches for certified green buildings lacking specific project names to establish suitable matches. Subsequently, this study employs the longitude and latitude data of the plots, along with information regarding the land acquisition company and project address obtained from *LandChina*, to align them with the longitude and latitude coordinates of the certified green building projects and their respective development companies. Through this process, this study successfully matches a total of 7,551 projects.

Figure 3.5 illustrates the distribution of certified green building projects and their proportion relative to the total number of projects. The certified green building projects were concentrated between 2013 and 2018. Due to the time gap between land acquisition and green building certification, the sample size for green building projects in 2019 and 2020 is relatively small. As shown in Figure 5, despite China's long-standing efforts in green building development, certified green buildings account for only 1.17% of all projects. This incongruity indicates a disparity between the actual progress of green building development in China and the extent of certification.

Table 3.1 Panel A presents summary statistics for certified green building land data from 2007 to 2020. This study includes 645,952 projects, of which 7,551 are green building projects. The average of certified green buildings and their ranking is 0.012 and 0.019, respectively. Furthermore, this study classifies certified green buildings into public, commercial, and residential categories. In research sample, public and commercial green buildings account for 0.2% of the total, while residential certified green buildings make up 0.7% of the projects.

Table 3.1 Panel C reports the summary statistics for land transaction characteristics from 2007 to 2020, covering 216 cities. In research sample, 50.8% of land transactions are conducted through listing, tendering and auction. 45.3% of the land was for residential use. Considering the substantial amount of land transferred without monetary compensation, this research introduced a dummy variable to represent land price. The dummy variable takes 0 for free land transfers and 1 for monetary value transactions. Furthermore, 70.6% of the land was exchanged for a fee. The average log of land area is -0.061.

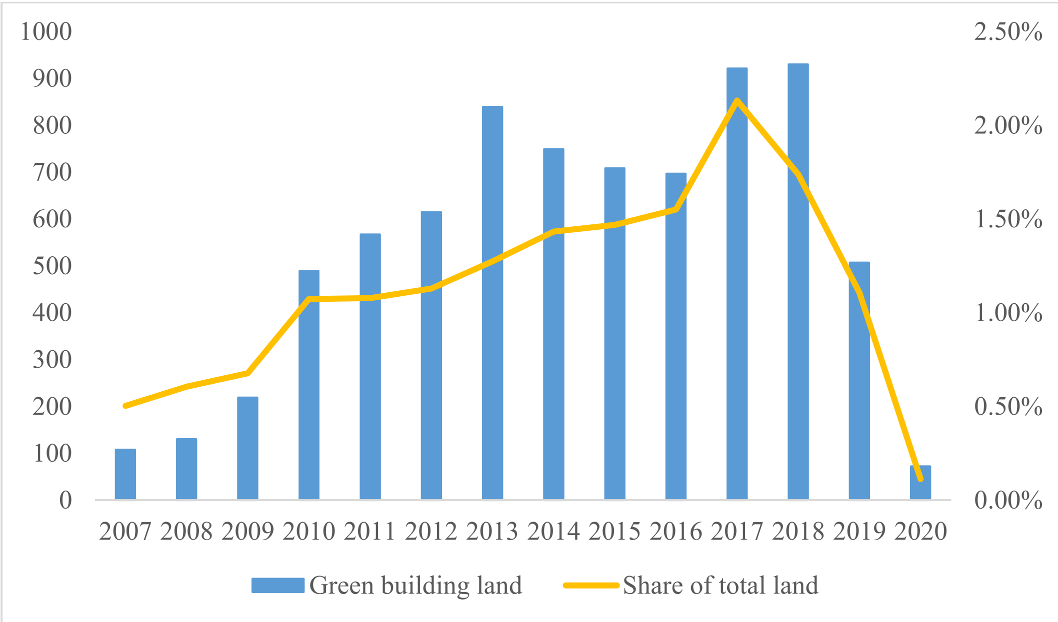

Figure 3.6 The distribution of certified green building plots and their proportion relative to the total land.

This figure illustrates the number of certified green buildings land and their share of total land between 2007 to 2020, covering 18 provincial administrative regions with 216 cities.

City-level macroeconomic

This study collects information on macroeconomic variables at the city level from 2006 to 2019, as provided by *the City Statistics Yearbook*, to control for the underlying economic conditions in the empirical model. Macroeconomic variables include the growth rate of gross domestic product (GDP), the GDP per capita, fixed asset investments, and the growth rate of the population. GDP growth rate (GDPGROWTH) is calculated by comparing the GDP of a given year with the GDP of the previous year. The GDP per capita (GDPPER) is the logarithm of GDP per capita. The fixed asset investment (FIXEDINVEST) is the ratio of fixed asset investment to the GDP. The population growth rate (POPGROWTH) is determined by considering the difference between the number of births and deaths and net migration (immigration minus emigration) during the specified period. The fiscal deficit (Deficit) is calculated as the difference between municipal fiscal revenue and expenditure divided by GDP.

Table 3.1 Panel D reports descriptive statistics for city-level macroeconomic variables. The average GDP growth rate and the log of the GDP per capita in research sample are 10.64% and 12, respectively. The average ratio of fixed asset investment to GDP, the population growth rate, and the fiscal deficit are 67.3%, 0.6% and 238.08%, respectively.

Table 3.1 Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Panel A: Green building certification variables					
GB	645,952	0.012	0.108	0	1
Ranking	645,952	0.019	0.186	0	3
Public	645,952	0.327	0.469	0	1
Commercial	645,952	0.220	0.414	0	1
Residential	645,952	0.453	0.498	0	1
Panel B: Green building assessment variables					
*Post*Treat*	645,952	0.249	0.432	0	1
Promotion	645,952	0.116	0.320	0	1
Non-promotion	645,952	0.326	0.469	0	1
Energy	645,952	0.235	0.424	0	1
Non-energy	645,952	0.208	0.406	0	1
Panel C: Land level control variables					
LTA	645,952	0.508	0.500	0	1
Price	645,952	0.706	0.456	0	1
Land type	645,952	0.453	0.498	0	1
Land area	645,902	-0.061	1.821	-9.361	10.625
Panel D: City level macroeconomic and environment attention control variables					
GDPGROWTH	645,952	0.120	0.084	-0.469	0.615
GDPPER	645,952	10.638	0.655	8.296	13.056
FIXEDINVEST	645,952	0.673	0.225	0.173	1.279
POPGROWTH	645,952	0.006	0.004	-0.002	0.021
Deficit	645,952	2.308	1.384	0.649	14.577

This table reports the summary statistics for all the datasets, including the green building certification project, green building assessment policy, land transaction database and city-level macroeconomic variables. The sample period is 2007 to 2020. Green building certification variables include the green building certification project (GB), certification level (Ranking), and green building type (Public, Commercial and Residential). Green building assessment variables also are contained, including the key independent variable *Treat*Post*, local officials promotion assessment (Promotion), non-promotion assessment (Non-promotion), local government energy-saving target assessment (Energy) and non-energy-saving assessment (Non-energy). Land-level variables include the land transaction approach (LTA), land transaction price (price), land transaction type (land type) and land transaction area (land area). It also provides the city-level macroeconomic variables, including the GDP growth rate (GDPGROWTH), the log of GDP per capita (GDPPER), the ratio of fixed asset investment to the GDP (FIXEDINVEST), population growth rate (POPGROWTH), and fiscal deficit (Deficit). The definition for these variables is displayed in Appendix A.

3.3.2. Methodologies

Propensity score matching and balance

In total, 112 cities have developed green building action plans in response to the central and provincial governments' call for such plans to be incorporated into local target responsibility systems. These cities form the treatment group. In contrast, the control group consists of 104 cities. Among these, 83 cities have formulated green building action plans in line with national policy but have yet to sign target responsibility contracts with officials. The remaining 21 cities have neither responded to central and provincial governments' calls nor introduced related policies. This research employs the PSM approach to construct a matched control group to evaluate the causal effect of green building target responsibility assessments on green building development. This method employs a logistic regression model and the nearest neighbour criterion. Propensity scores are calculated based on macroeconomic characteristics and city carbon emissions. The selection of nearest neighbours is based on eight city-level characteristics: GDP, GDP per capita, GDP growth rate, population growth rate, the ratio of fixed asset investment to GDP, the proportion of secondary and tertiary industries in GDP, fiscal deficit, and carbon emission intensity. For each characteristic, this study considers the variable in the year prior to the release of the national green building action plan and the "pre-trend" (i.e., the change from t-5 to t-1).

The nearest neighbour city is identified as the one with the smallest distance to the treated city based on these eight matching characteristics.

The matching procedure aims to ensure a high degree of similarity between the control cities and the treated cities. This study eliminates concerns about better growth opportunities in treated cities by employing macroeconomic indicators. Furthermore, incorporating carbon emission intensity as a matching feature, this study ensures similar environmental performance between treated and control cities before implementing green building assessments. This approach guarantees that treated and controlled cities face similar macroeconomic and carbon emission pressures.

Table 3.2 provides descriptive statistics for eight matching characteristics in treatment and control cities before and after matching. These characteristics, such as GDP per capita (GDPPER), are measured one year prior to policy implementation (t-1). The pre-trends, represented by changes in ΔGDPPER, capture the variations observed during the first five years leading up to policy implementation (from t-5 to t-1). The table includes the mean values of these characteristics for both the treatment and matched control cities, along with the p-values from the mean difference tests. Overall, treatment and control cities demonstrate remarkable similarity across all these characteristics. This similarity provides substantial support for reliable counterfactual hypotheses.

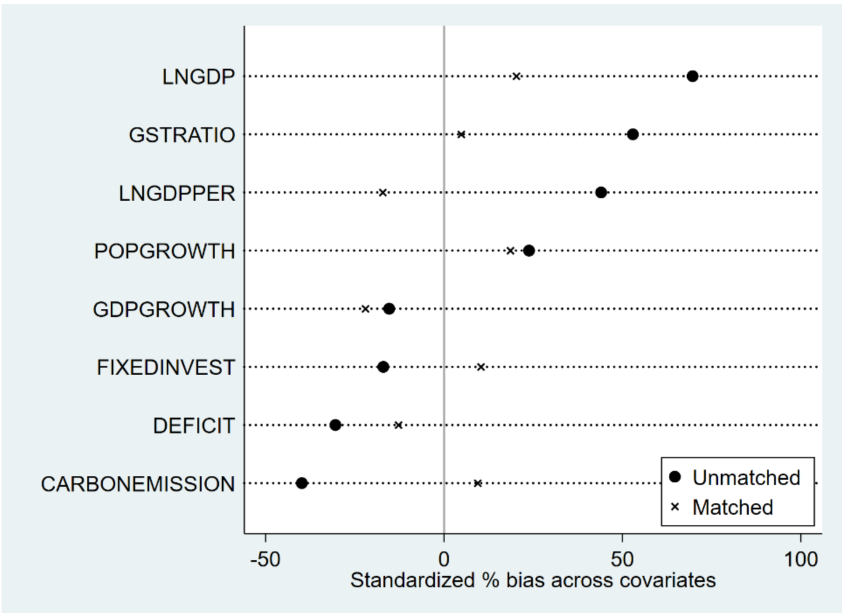

Figure 3.7 Standardized bias of the PSM

Table 3.2 Balance test of the PSM

Variable		Mean	P-value
GDPPER	Treated	10.384	0.062*
	Matched control	10.150	
Log (GDP)	Treated	16.344	0.010***
	Matched control	15.835	
GDPGROWTH	Treated	17.150	0.516
	Matched control	17.692	
DEFICIT	Treated	235.030	0.224
	Matched control	272.830	
GSTRATIO	Treated	87.445	0.023**
	Matched control	83.043	
FIXEDINVEST	Treated	62.567	0.458
	Matched control	65.709	
POPGROWTH	Treated	0.519	0.394
	Matched control	0.435	
CARBONEMISSION	Treated	2.153	0.094
	Matched control	2.920	
Δ GDPPER	Treated	10.374	0.227
	Matched control	10.465	
Δ Log (GDP)	Treated	16.335	0.134
	Matched control	16.187	
Δ GDPGROWTH	Treated	17.255	0.078*
	Matched control	18.032	
Δ DEFICIT	Treated	234.910	0.332
	Matched control	250.790	
Δ GSTRATIO	Treated	87.725	0.677
	Matched control	87.327	
Δ FIXEDINVEST	Treated	63.902	0.479
	Matched control	62.000	
Δ POPGROWTH	Treated	0.513	0.146
	Matched control	0.448	
Δ CARBONEMISSION	Treated	2.195	0.463
	Matched control	2.014	

This table reports descriptive statistics for PSM. The levels of these characteristics, such as GDPPER, are measured one year prior to the implementation of the policy (t-1). The pre-trends, represented by ΔGDPPER, capture the changes observed during the initial five years of policy implementation (from t-5 to t-1). The mean values and p-values of the mean difference tests are reported for each characteristic.

The matching characteristics include the log of GDP (GDP), GDP growth rate (GDPGROWTH), the log of GDP per capita (GDPPER), population growth rate (POPGROWTH), the ratio of fixed asset investment to GDP (FIXEDINVEST), the proportion of secondary and tertiary industries in GDP (GSTRATIO), fiscal deficit (DEFICIT), and carbon emission intensity (CARBONEMISSION). Statistical significance levels are denoted by *, **, and *** for the 10%, 5%, and 1% levels, respectively.

Cross-sectional analysis

This study investigates whether voluntarily integrating green building targets into the target responsibility system promotes green building practice. The empirical strategy leverages the staggering implementation of the target responsibility assessment policy across cities to identify the causal effect. The baseline specification employs the difference-in-difference (DID) estimator that compares the outcome variables in the cities that have adopted the target responsibility system on the green building practice relative to other cities without the green building target responsibility assessment each year. The regression is specified as below:

$$GB = \beta_0 + \beta_1 Treat * Post + \beta_2 \eta_{i,c,y} + \beta_3 X_{c,y-1} + \lambda_c + \theta_y + \varphi_t + \varepsilon_{c,y} \quad (4.1)$$

Where the dependent variable *GB* is a dummy variable, equal to one if the land is transferred to build green building and zero otherwise. *Treat* equal to one if the city implements a green building target responsibility system for green buildings and zero otherwise. *Post* is one for years after the green building action plan implementation. $\eta_{i,c,y}$ comprises a range of land characteristic variables such as land type, land area, land price and land transfer method. $X_{c,\,y-1}$ constitutes city-level control variables like GDP per capita, GDP growth rate, population growth rate, the ratio of fixed asset investment to GDP, and fiscal deficit, all lagged by a year. The model incorporates City (λ_c), Year (θ_y) fixed effects, and the linear treatment-specific time trend (φ_t) to address potential divergences in time trends between the treatment and control groups.

Staggered DID estimates may be biased due to time-varying treatment effects or heterogeneity within the sample groups. To overcome this concern, this study employs a specification that uses the event study DID method. Specifically, this study estimates the effects for the six years preceding the green building action plan implementation and the five years following it.

$$GB = \beta_0 + \sum_{j=-6}^{5} \beta_j \, Treat_{c,y+j} + \beta_2 \eta_{i,c,y} + \beta_3 X_{c,y-1} + \lambda_c + \theta_y + \varphi_t + \varepsilon_{c,y} \quad (4.2)$$

The analysis introduces the indicator variable $Treat_{c,y+j}$ to represent the time when the city implements the green building target responsibility assessment. For example, $Treat_{c,y-3}$ corresponds to the three years prior to the policy implementation. The control group, denoted by J = -1, represents the year immediately preceding the policy implementation and is excluded from the regression analysis. This approach helps identify potential biases arising from staggered treatment timing and allows for evaluating and validating the parallel trend assumption inherent in the DID analysis.

3.4. Empirical results

3.4.1. Effect of the green building assessment policy on green building development

Empirical results regarding the effect of voluntarily integrating green building targets into the target responsibility system are reported in Table 3.3. The coefficient in Column (1) captures the effect of green building target responsibility assessment on green building development without including the land and city-level control variables. The interaction term *Post*Treat* in column 1 is both positive and significant at 5% level. Column (2) of Table 3.3 reports the DID estimation results corresponding to specification (4.1). The coefficient of *Post*Treat* is 0.0033 and significant at 5% level. This study compares the estimates to the sample mean to gauge the economic magnitude of the estimated effects. As provided in Table 3.1, the mean value of the outcome variable GB over the sample period is 0.012. The results suggest that integrating green building development into the target responsibility system increases green building by 27.5% relative to the sample mean. These results indicate that the number of certified green buildings has increased over the years after the voluntary integration of green building targets into the target responsibility system.

Table 3.3 The effect of voluntarily integrating green building targets into the target responsibility system

	(1) GB	(2) GB
*Post*Treat*	0.0039**	0.0033**
	(2.33)	(2.08)
Constant	0.0107***	-0.0369
	(21.86)	(-0.41)
Control	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
City-specific time trends	Yes	Yes
Observations	645952	645902
R-squared	0.0331	0.0401

This table reports the effect of voluntarily integrating green building targets into the target responsibility system. *GB* is a dummy variable whether the land is transferred to build green buildings. *Treat* is a dummy variable for the city that implements green building target responsibility system and *Post* is a dummy variable to indicate whether observations are after the green building development policy implementation. Land control variables include land type, land area, land price and land transfer method. City-level control is a set of city macroeconomics, including GDPGROWTH, GDPPER, FIXEDINVEST, POPGROWTH, and Deficit, all lagged by a year. City fixed effects, year fixed effects and the linear treatment-specific time trend are included in the model. Robust standard errors clustered at the city for each year are in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

3.4.2. Heterogeneity analysis

Table 3.3 provides the average effect of voluntarily integrating green building targets into the target responsibility system on green building practice. This study next investigates whether these effects vary as a function of the developer attributes. This study examines government-led and private developer projects, with the findings in columns (1) and (2) of Table 3.4. The results show that the interaction term of *Post*Treat* is positively and significantly associated with government-led projects, while it is not significant in private developer projects. These findings demonstrate that this target responsibility policy primarily influences government actions and encourages them to adopt more green buildings. However, it has not yet established a long-term mechanism to promote market-driven development of green buildings, nor does it effectively mobilize the private sector in green building initiatives.

The green building target responsibility assessment employs two primary approaches. First, it is integrated into the local government's energy-saving target responsibility system, where local governments evaluate building energy efficiency and green building development. However, this assessment constitutes only 5% of the total energy-saving target responsibility score. Second, green buildings are included in the cadre evaluation system, which considers officials' performance in promoting green building development during their promotion process. Additionally, some local governments incorporate green building targets into their annual work assessment and performance evaluation to ensure adequate attention and promotion at the governmental level. This study constructs four variables to examine the impact of these various assessment approaches on green building development. *Promotion* is a dummy variable indicating inclusion in the cadre evaluation post-policy promulgation. *Non-promotion* is a dummy variable indicating integration in the energy-saving targets responsibility system, annual work and government performance assessment post-policy promulgation. *Energy* is a dummy variable indicating integration in the energy-saving targets responsibility system post-policy promulgation. *Non-energy* is a dummy variable that includes the assessment into officials' cadre promotion, government annual work and government performance post-policy promulgation. Columns (3) and (4) of Table 3.4 indicate that cadre promotion assessments are more effective in driving the development of green buildings than energy conservation assessments. When China's cadre assessment system incentivizes local officials for their environmentally-friendly actions, these officials will forsake their previous focus on unrestricted economic growth and address the nation's environmental crisis (Wu and Cao, 2021).

Table 3.4 The heterogeneity effect of the green building target responsibility assessment on green building practices

	(1) GB Government	(2) GB Private	(3) GB	(4) GB
*Post*Treat*	0.0037**	0.0028		
	(2.48)	(1.44)		
Promotion			0.0067***	
			(2.58)	
Non-promotion			0.0045***	
			(3.29)	
Energy				0.0041**
				(2.49)
Non-energy				0.0060***
				(3.68)
Constant	0.0466	-0.0713	-0.0384	-0.0409
	(0.78)	(-0.67)	(-0.43)	(-0.46)
Control	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City-specific time trends	Yes	Yes	Yes	Yes
Observations	215592	430310	645902	645902
R-squared	0.0410	0.0453	0.0402	0.0402

This table reports the heterogeneity effect of voluntarily incorporating green building targets into the target responsibility system. *GB* is a dummy variable for whether the land is transferred to build green buildings. *GB* government is a dummy variable whether the land is transferred to build government green buildings. *GB* private is a dummy variable determining whether the land is transferred to build a private green building. *Treat* is a dummy variable for the city that implements green building target responsibility system, and *Post* is a dummy variable that indicates whether observations are after the green building development policy implementation. *Promotion* is a dummy variable indicating integration in the cadre assessment post-policy promulgation. *Non-promotion* is a dummy variable indicating inclusion in the energy-saving targets responsibility system, annual work and government performance assessment post-policy promulgation. *Energy* is a dummy variable indicating integration in the energy-saving targets responsibility system post-policy promulgation. *Non-energy* is a dummy variable that indicates inclusion the assessment into government cadre promotion, annual work, and government performance post-policy promulgation. Land control variables include land type, land area, land price and land transfer method. City-level control is a set of city macroeconomics, including GDPGROWTH, GDPPER, FIXEDINVEST, POPGROWTH, and Deficit, all lagged by a year. City fixed effects, year fixed effects and the linear treatment-specific time trend are included in the model. Robust standard errors clustered at the city for each year are in parentheses.*** p<0.01, ** p<0.05, * p<0.10.

3.4.3. Characteristics of green building

In this section, this study examines specific characteristics of certified green buildings to provide further evidence. This study focuses on two specific characteristics: the grade and type of certified green buildings. These characteristics are used as dependent variables in estimating equation (4.1). This study first investigates the quality of certified green buildings. This study uses the certification rating to evaluate the quality of green buildings. A higher rating signifies superior environmental friendliness, resource conservation, and sustainability. Column (1) of Table 3.5 provides the result. This study observes a positive and significant relationship in the interaction term between *Post*Treat*. Empirical results suggest that the target responsibility system promotes green building practices and enhances their quality, encouraging project developers to adhere to higher green building standards.

Next, this study examines the different types of green buildings: public, commercial, and residential green buildings. The corresponding findings are displayed in Columns (2)-(4) of Table 3.5. The analysis demonstrates a positive and significant coefficient for public green buildings, while the coefficients for commercial and residential green buildings are insignificant. These results indicate that the development of certified green buildings for commercial and residential purposes has not changed significantly following the target responsibility system. These results further support the findings displayed in Table 3.4, which suggest that the government has assumed responsibility for promoting green buildings, while private developers have not been sufficiently incentivized.

Table 3.5 Characteristics of green building

	(1) Ranking	(2) Public	(3) Commercial	(4) Residential
*Post*Treat*	0.0056**	0.0055***	0.0019	0.0020
	(2.32)	(3.16)	(1.12)	(0.86)
Constant	-0.0215	-0.0206	-0.0421	-0.0172
	(-0.18)	(-0.34)	(-0.43)	(-0.17)
Control	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City-specific time trends	Yes	Yes	Yes	Yes
Observations	645902	211444	141872	292586
R-squared	0.0344	0.0335	0.0450	0.0558

This table provides the effect of voluntarily incorporating green building targets into the target responsibility system on characteristics of green building. *Ranking* is green building certification level. *Public* is a dummy variable whether the land is transferred to build public green buildings. *Commercial* is a dummy variable of whether the land is transferred to build commercial government green buildings. *Residential* is a dummy variable whether the land is transferred to build a residential green building. *Treat* is a dummy variable for the city that implements green building target responsibility system, and *Post* is a dummy variable that indicates whether observations are after the green building development policy implementation. Land control variables include land type, land area, land price and land transfer method. City-level control is a set of city macroeconomics, including GDPGROWTH, GDPPER, FIXEDINVEST, POPGROWTH, and Deficit, all lagged by a year. City fixed effects, year fixed effects and the linear treatment-specific time trend are included in the model. Robust standard errors clustered at the city for each year are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

3.4.4. Robustness tests

Testing for variation over time

To verify the validity of the parallel trends assumption between the outcome variables of the control and treatment groups prior to the voluntary green building target responsibility assessment policy event, this study employs specification (4.2) to examine the time dynamics (see Figure 3.8). This study focuses on the interaction term between treatment and time. When the coefficient of the pre-treatment period does not differ significantly from the baseline period (one year prior to the issuance of the green building policy), this study can deduce that the certified green buildings in the treatment group and the control group do not differ significantly. The results demonstrate that the identification assumption in the DID regression is valid.

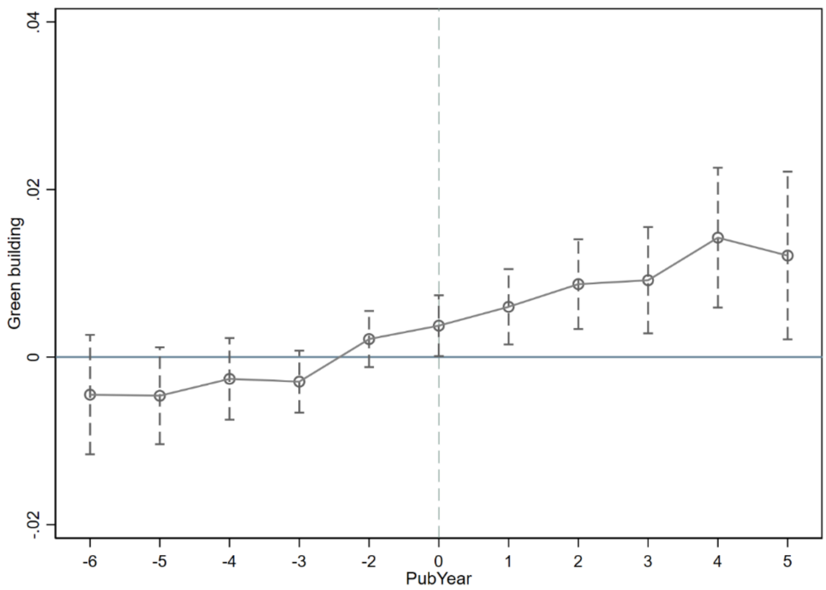

Figure 3.8 Parallel trends

This figure reports the result of the assumption of parallel trends. We estimate the effects for the six years preceding the green building assessment policy implementation and the five years following it.

Placebo test

The findings suggest that the voluntary integration of green building targets into the target responsibility system can foster green building initiatives. However, it is crucial to acknowledge that unobservable random factors and other policies may influence the observed effects of policy implementation. To ensure the accuracy of the estimates, this study follows Liu et al. (2022) and employ a placebo test to randomly assign a treatment group that has integrated green building targets into the target responsibility system and a control group that has not implemented such actions. Additionally, this study randomly assigns the year of policy implementation to both the treatment and control groups. Specifically, this study randomly assigns 112 cities as the treatment group, assuming that these cities have incorporated green building targets into the target responsibility system. The other 104 cities form the control group on the assumption that these cities have never published such a policy. This study re-estimates the baseline model (4.1) to validate the findings using the new sample 500 times.

Figure 3.9 illustrates the distribution of the 500 estimated coefficients of the interaction term *Post*Treat* and their corresponding p-values. The analysis reveals that the coefficients from the simulated exercise tend to cluster near zero, with most estimates being statistically insignificant at the 10% level. In addition, the baseline estimates this study reports in Table 3.3 exceed a significant portion of the coefficients obtained from 500 random samples. These findings suggest that the results are unlikely to be attributed to chance. Therefore, they provide substantial support for the conclusion that a voluntary green building target responsibility system encourages green building adoption.

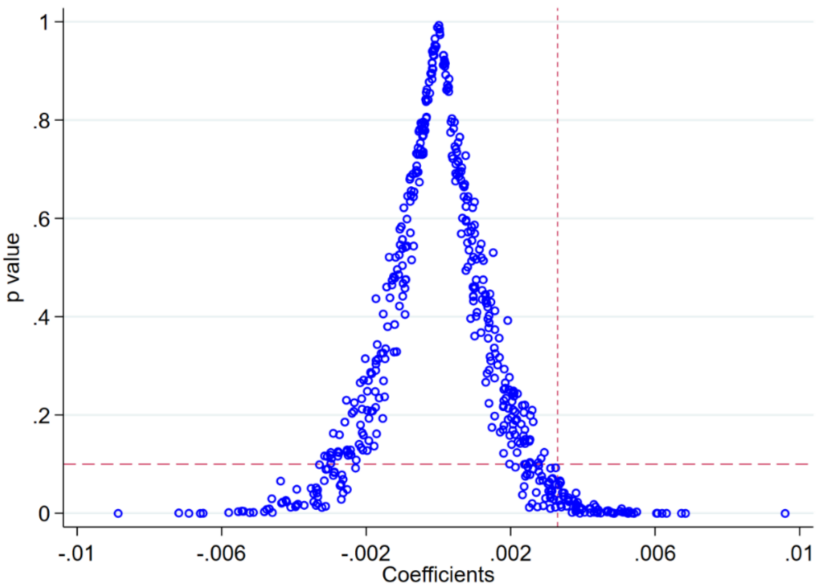

Figure 3.9 Placebo test

This Figure provides the placebo test results by randomly fabricating the experimental group and policy year. 112 cities in the same were randomly selected into pseudo treatment group. This study runs placebo tests by re-estimating the specification 4.1 for GB in 500 random samplings.

Eliminate interference from other policy

In 2009, China set a target for controlling greenhouse gas emissions. To achieve this binding target and address climate change, the central government initiated low-carbon policy pilots in select cities starting in 2010. Several low-carbon pilot cities were established in China between 2011 and 2017, with the first batch implementing policies in 2011. The research sample includes 96 cities within the scope of low-carbon pilot cities. Considering the significant influence of low-carbon pilot policies on government and enterprise behaviour in the pilot areas, mitigating the policy's interference with the research findings is essential. Therefore, this study proposes an estimation variable using the low-carbon city pilot policy and introduce it as a control variable in specification 4.1 to test the DID estimator. The results in column (1) of Panel A in Table 3.6 demonstrate that the *Post*Treat* coefficient is significant and positive at the 1% level. This finding suggests that after accounting for the impact of low-carbon pilot cities on green buildings, the voluntary green building target responsibility system continues to promote the construction of green buildings. Therefore, the findings remain robust.

Results using sub-samples

Economic development and environmental governance appear to differ between provincial capitals, sub-provincial cities, and general prefecture-level cities. Moreover, provincial capitals and sub-provincial cities occupy a higher position in the political hierarchy than general prefecture-level cities (Chen et al., 2018). Considering these administrative and economic distinctions, this study excludes provincial capitals and sub-provincial cities from research sample. Column (2) of Panel A in Table 3.6 shows that the coefficient is positive and significant. The result indicates that the result is not driven by specific subsamples.

Measurement the certified green building at city level

The primary research focuses on certified green buildings at the land level. This section examines the impact of voluntarily incorporating green building development into the target responsibility system by constructing variables for certified green buildings at the city level. This study calculates the ratio of green building land granted annually to the total land granted in the city, defining this ratio as the *GB City* variable. This methodology is employed to derive the *GB Public* and *GB Private* variables. The interaction terms of *Post*Treat* in Columns (1) of Panel B in Table 3.6 demonstrate significance at the 1% level, indicating that the ratio of certified green buildings at the city level increased after implementing the green building target responsibility system. Columns (2) and (3) of Panel B in Table 3.6 provide the regression results for *GB public* and *GB private* at the city level. This study finds that the coefficients of *Post*Treat* are positive and statistically significant. Therefore, the results remain robust.

Table 3.6 Robustness tests

Panel A eliminating interference from other policies and using sub-samples		
	(1)	(2)
	GB	GB
*Post*Treat*	0.0033**	0.0030***
	(2.09)	(2.70)
Constant	-0.0313	0.0167
	(-0.35)	(0.62)
Control	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
City-specific time trends	Yes	Yes
Observations	645902	528741
R-squared	0.0402	0.0262

Panel B: measure the certified green building at the city level			
	(1)	(2)	(3)
	GB City	GB Public	GB Private
*Post*Treat*	0.59***	0.60***	0.63**
	(3.00)	(2.75)	(2.24)
Constant	2.08	-1.25	6.76
	(0.24)	(-0.21)	(0.67)
Control	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
City-specific time trends	Yes	Yes	Yes
Observations	3024	3021	3024
R-squared	0.6243	0.3504	0.5902

Panel A reports the robustness tests by eliminating interference from other policies and using sub-samples. *GB* is a dummy variable for whether the land is transferred to build green buildings. Panel B reports the robustness tests by measuring the certified green building at the city level. *GB City* is the certified green building project ratio to the city's total building project in a year. *Treat* is a dummy variable for the city that implements green building target responsibility system, and *Post* is a dummy variable that indicates whether observations are after the green building development policy implementation. Land control variables include land type, land area, land price and land transfer method. City-level control is a set of city macroeconomics, including GDPGROWTH, GDPPER, FIXEDINVEST, POPGROWTH, and Deficit, all lagged by a year. City fixed effects, year fixed effects and the linear treatment-specific time trend are included in the model. Robust standard errors clustered at the city for each year are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

3.4.5. How does the green building target responsibility system spur the green building development

This study has demonstrated that incorporating green buildings into the target responsibility system significantly promotes green building development. In this section, this study evaluates potential channels or mechanisms underlying this effect.

The first explanation is the local governments' disclosure of pollution and emissions reduction efforts. This study constructs a government environmental attention index to evaluate this mechanism's effectiveness. This study extracts pertinent data from the Government Work Report to gauge the government's focus on environmental issues. These reports summarize local jurisdictions' social and economic achievements over the past year and outline goals for the following year. As environmental concerns have gained prominence, the Chinese government has increasingly incorporated environmental governance policies in its annual work reports. Following the methodology of Chen et al. (2018), this study identifies environmental sentences by extracting those containing terms such as "environment," "energy consumption," "pollution," "carbon emission reduction," and "environmental protection". This study then calculates the percentage of environmental texts in each city's report to measure government attention to environmental issues. Column (1) of Table 3.7 provides the regression results. This study finds that *Post*Treat* is positive and statistically significant. The findings indicate that city governments under the voluntary green building target responsibility assessment exhibited a heightened focus on reducing emissions than non-assessed cities, increasing green building construction.

The second explanation is a public environmental concern. Local governments have implemented publicity and educational efforts to raise public awareness of green building development to meet assessment targets. Public concern about environmental issues is a prerequisite for participation in environmental governance (Besley and Persson, 2023). Green buildings save energy and provide a healthy living environment. Therefore, the government actively promotes green building policies, disseminates best practices, and shares technical knowledge to improve public awareness and understanding. These efforts foster green consumption, encouraging the public to choose green buildings when purchasing or leasing properties. The consumer demand, in turn, motivates developers to prioritize green buildings. This study constructs a public environmental concern index at the prefecture-level to investigate this channel using the Baidu Index. Following Wu et al. (2022), this study collects the public search index on environmental issues, including pollution and haze, from the Baidu Index. The Baidu Index is categorized into three types based on search channels: total search index, PC search index, and mobile search index. The total search index is the weighted sum of PC and mobile search indices. This study converts the daily total search index into an annual search index to measure public environmental concerns. Column (2) of Table 3.7 finds that the estimated coefficient of *Post*Treat* is 1.65, significant at the 1% level. The finding suggests that after integrating the green building targets into the target responsibility system, public concern for the environment increases by 1.65%. This result suggests that encouraging public participation in environmental governance can create synergies between the government and the market, thereby ensuring sustained environmental improvement.

The third potential channel is financial incentives. Governments may offer financial incentives such as tax concessions, low-interest loans, and subsidies to encourage green building development. These incentives can reduce the cost of green buildings, increase the return on investment, and encourage more developers and owners to adopt green building practices and technologies. To evaluate the merit of this explanation, this study examines whether the voluntary implementation of the governmental target responsibility system leads to an increase in local financial incentives for supporting green building development. This study has compiled a list of financial incentives provided to developers under the government's Green Building Action Plan. These incentives encompass subsidies, tax benefits, preferential loan interest rates, plot ratio incentives, enhanced corporate credit scores, expedited approval processes, and preferential land transfers. If a local government incorporates any of these incentives into its green building action plan, it indicates the presence of financial support mechanisms for green building development in that city. The regression results are shown in Column (3) of Table 3.7. The coefficient of *Post*Treat* is positive and statistically significant. The findings suggest that the governments of the assessed cities introduce more financial incentives to support the adoption of green buildings compared to non-assessed cities.

3.4.6. The consequences of green building target responsibility system

In this section, this research investigates the potential benefit of voluntarily integrating green building targets into the government's performance evaluation system, particularly its effectiveness in reducing urban carbon emissions. Green buildings consume less energy and emit fewer greenhouse gases during construction and operation than conventional ones. Therefore, if the policy is credible, this study should observe a significant reduction in urban carbon emissions. This study uses urban carbon intensity to assess this outcome. Considering the policy's delayed effect, this study lags the *Post*Treat* by one period for the analysis. The regression result is presented in Column (4) of Table 3.8 and shows that the coefficient of *Post*Treat* is negative and significant. This finding indicates that the carbon intensity of the assessed cities decreased by 8% following the implementation of the evaluation policy. This finding aligns with Chen et al. (2018), who report that performance target evaluation policies can enhance local officials' willingness to reduce SO2 emissions.

Table 3.7 The channel and consequences for the impact of green building target responsibility system

	(1)	(2)	(3)	(4)
	Government environmental attention	Public environmental concern	Financial Incentives	Carbon Intensity
*Post*Treat*	0.02**	1.65***	0.78***	-0.08**
	(2.21)	(2.79)	(46.30)	(-2.41)
Constant	0.34***	-21.12	0.25***	9.93***
	(16.85)	(-1.35)	(6.92)	(9.06)
Control	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	2994	2160	3024	2800
R-squared	0.3919	0.9338	0.8982	0.9883

This table reports the channel and consequence of the impact of the green building target responsibility system. *Government Environmental Attention* refers to the frequency of environmental terms in government work reports. *Public Environmental Concern* denotes the annual index of the public's use of Baidu for environment-related searches. *Financial Incentives* are a dummy variable, equal to 1 when the government provides financial support for green buildings and 0 otherwise. *Carbon Intensity* is urban carbon emissions divided by GDP. *Treat* is a dummy variable for the city that implements green building target responsibility system, and *Post* is a dummy variable that indicates whether observations are after the green building development policy implementation. City-level control is a set of city macroeconomics, including GDPGROWTH, GDPPER, FIXEDINVEST, POPGROWTH, and Deficit, all lagged by a year. City fixed effects and year fixed effects are included in the model. Robust standard errors clustered at the city for each year are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

3.5. Conclusions

This research investigates the effect of voluntarily incorporating green building development into the governmental target responsibility system. Using a comprehensive dataset that this study constructed, the empirical results substantiate the effectiveness of a target-oriented performance evaluation system in advancing governmental green building initiatives. Specifically, incorporating green building development targets within the evaluation system is associated with a marked increase in green buildings. However, heterogeneity analyses reveal that this growth is predominantly observed within the government sector, with negligible spillover into the private sector. Moreover, incorporating green building targets into the cadre evaluation system proves to be more effective than integrating them solely into the energy efficiency targets responsibility system.

This study examines three key mechanisms through which integrating green building development into the target responsibility system influences green practices. This policy increases government attention to environmental issues, prompting local authorities to adopt green initiatives. Additionally, it cultivates green values and awareness among the public, which drives demand for green buildings. The government also offers financial incentives to developers and owners to support green building practices. Furthermore, as an urban mitigation strategy, the green building target responsibility system effectively reduces urban carbon footprints.

Overall, the findings suggest that government-led urban mitigation policies can effectively motivate local governments to address carbon emissions concerns. However, the research highlights a gap in engaging market participants. Evidence shows that market-driven environmental regulations can inspire firms' commitment and offer a sustainable energy conservation and emission reduction mechanism. Consequently, in devising government-led emission reduction policies, it is imperative to engage the market and foster synergies between governmental and market mechanisms to support sustainable growth.

Chapter 4. State Ownership and National Commitment in Carbon Neutrality

4.1. Introduction

This chapter explores whether Chinese State-owned enterprises (SOEs)[3] are engaged more for achieving carbon neutrality commitment by examining market reactions to China's announcement of its goal to achieve peak carbon emissions and subsequent carbon neutrality. SOEs are among the most influential actors in the global economy and are considered vehicles for national development strategies (Szarzec et al., 2021). Public goods such as energy, transportation and infrastructure, are operated primarily by SOEs and account for a significant proportion of global greenhouse gas emissions (Mayer and Smith, 2023). SOEs are responsible for more than a fifth of all direct carbon emissions worldwide (Clark and Benoit, 2022). China commits that it will adopt stronger policies and measures to reach carbon neutrality, which could give pressures to SOEs on decarbonisation. Globally, countries rely on SOEs' involvement to meet their climate commitments and achieve successful decarbonisation (Mayer andd Rajavuori, 2017; Prag et al., 2018). Yet, it is not clear how SOEs would respond to the call from governments in achieving carbon neutrality goals, whether they will pay (more) genuine efforts to decarbonise their activities, and whether their financial performance will be harmed because of their mandate responsibilities in reducing carbon emissions. This study investigates this question by exploring whether SOEs have a stronger negative stock market reaction to carbon neutrality commitment, which is perceived as genuine decarbonisation efforts by stock market investors, than non-SOEs.

This study firstly applies an event study method to capture changes in the stock prices of Chinese listed firms in response to the announcement (i.e., the event). A negative change in a firm's stock returns following the event would indicate that the market envisions a negative impact of China's carbon neutrality commitment on the firm's long-term financial performance (Keele and Dehart, 2011; Jin et al., 2020), which

[3] A state-owned enterprise is one in which the state owns at least 50% of the shares and is the largest shareholder.

can be attributed to efforts to reduce emissions subsequent to the announcement. In a sample of 2,792 firms in China, we find that the overall market reactions to the carbon neutrality commitment are significant and negative, indicating that the commitment is credible and is expected to adversely affect corporate financial performance (Gao et al., 2022). This study observes a much stronger negative market reaction among SOEs than among non-SOEs, which implies that SOEs will be more strongly affected by the government's actions related to its carbon neutrality commitment. This study also finds that SOEs with direct responsibility conferred by the central government, such as central state-owned enterprises (CSOEs) and SOEs with high corporate social responsibility (CSR) scores, have more stronger stock market reactions to the commitment. Collectively, the results show that SOEs are expected to take more actions to reduce carbon emissions, and hence, the market considers SOEs to be more socially responsible than non-SOEs in terms of achieving carbon neutrality, suggesting that state ownership can facilitate national decarbonisation.

In addition, this research employs DID model to investigate the effect of carbon neutrality commitment on firm value and carbon intensity using a firm-year sample before and after the announcement of carbon neutrality commitment. The DID estimation results show that firm value, as well as carbon emissions intensity, is reduced more after carbon neutrality commitment than non-SOEs. These results provide further support to the argument that SOEs are more responsible for achieving the goal of carbon neutrality, exert more efforts to reduce carbon emissions, and experience more negative impact of decarbonisation activities on firm value.

The remainder of this chapter is organised as follows. Section 4.2 includes a review of the literature and development of the research hypothesis. Section 4.3 contains the proposed empirical strategy and descriptions of the data and variables. Section 4.4 displays the empirical results. Section 4.5 concludes this chapter.

4.2. Literature review and hypothesis development

This research is related to the literature on the relationship between state ownership and environmental performance. SOEs are major contributors to global pollution. Studies find that SOEs emit more pollutants than private firms due to their use of bureaucratic connections to evade pollution regulations (e.g., Meyer and Pac, 2013) and the energy inefficiency of SOEs (e.g., Andersson et al., 2018). Meyer and Pac (2013) compare the environmental performance of state-owned utilities and privately owned utilities in Eastern Europe and find that state-owned factories emit more sulphur dioxide pollution because they use their ties to the government to evade government regulations. Andersson et al. (2018) examine China's provincial panel dataset and find that the majority of China's carbon dioxide emissions are produced by SOEs. The large amounts of emissions generated by SOEs can be attributed to their low energy efficiency. However, some studies argue that state ownership may encourage SOEs to more actively reduce their emissions. In a research of 29 European countries, Clò et al. (2017) find that state ownership positively impacts the environmental performance of these countries' electricity sectors. In that study, greenhouse gases are shown to be emitted less by government-controlled companies than by private companies. Wang et al. (2019) investigate the impact of ultimate ownership on firm carbon reduction engagement and show that SOEs more actively reduce carbon emissions than do private enterprises. Liang and Ma (2020) find that SOEs reduce energy consumption by about 19.9% more than do non-SOEs in China's Thousand Enterprises Energy Conservation Program. Liang and Langbein (2021) find that, in general, the dominance of SOEs in the provincial economy positively impacts realisation of the government's environmental pollution control goals. Wang et al. (2022) discover that SOEs exhibit higher sensitivity than private enterprises to government requirements: under the government's target requirements, SOEs emit 7.13% less sulphur dioxide than private enterprises.

Despite the contradictory results of research on the impact of state ownership on environmental performance, SOEs in China are generally regarded as the most reliable corporate responders to the state's environmental policies (Guo et al., 2020; Chen et al., 2022; Wang and Zhang, 2022). Compared with non-SOEs, SOEs are assigned more tasks in energy conservation programmes (Guo et al., 2020), more actively participate in China's Carbon Emissions Trading Scheme (Wang and Zhang, 2022) and assume more carbon emission reduction responsibilities in cities targeted by China's low-carbon pilot policies (Chen et al., 2022). Given the importance of the national government's climate commitment to carbon neutrality, the Chinese government is expected to entrust SOEs with a large proportion of the responsibility for achieving carbon neutrality due to these enterprises' social attributes. To fulfil these obligations, SOEs are anticipated to increase environmental investments to intensify their efforts in carbon emission reduction. However, such efforts are likely to result in increased operating costs and reduced profit margins for SOEs. Additionally, the decarbonization policy implemented by the government necessitates the optimization and transformation of industrial structures within SOEs to achieve carbon neutrality. For example, SOEs in carbon intensive industry are required to divest from profitable traditional fossil energy sources, which may cause short-term financial performance setbacks. Consequently, it is expected that the announcement of the carbon neutrality commitment will lead to increasingly negative market reactions for SOEs.

Hypothesis 1 (H1): Compared with non-SOEs, SOEs face a stronger negative market reaction to carbon neutrality commitment.

China's policy implementation structure comprises top-down control and bottom-up experimentation, whereby the central government takes the lead in setting policy agendas but implementation of the agendas is delegated to local governments (Wang et al., 2018). The central (local) government administratively and politically controls central (local) SOEs. The government administrative level may affect business behaviour, leading to differences in the performance of SOEs at different levels (Luo et al., 2016; Liang and Ma, 2020). As entities directly supervised by the central government, CSOEs receive considerable attention from the media and public. CSOEs lead their industries in implementing central policies and are superior to local SOEs (LSOEs) in such implementation (Luo et al., 2016). For example, in the Thousand Enterprises Energy Efficiency Programme issued by the Chinese government, CSOEs have been the leaders in achieving the policy's goals, saving about 15.18% more energy than their local counterparts (Liang and Ma, 2020).

As the distance across the administrative hierarchy increases, the central government cannot monitor the extent to which local governments implement environmental policies. As a result, the central government places less pressure on LSOEs than on CSOEs in terms of environmental practices (Wang et al., 2018). Large LSOEs are usually the main contributors to their local economies (Liang and Ma, 2020). Local governments in China heavily prioritise economic development and hence need large SOEs to generate sufficient revenues to support local economic systems (Koppell, 2007). Thus, local governments usually have less bargaining power than LSOEs in negotiations about environmental performance mandates (Yu et al., 2022) and give

SOEs considerable flexibility and autonomy to determine their environmental goals (Wang et al., 2018). Furthermore, to maintain local economic growth, local governments may be reluctant to impose stringent carbon reduction tasks on LSOEs (Lorentzen et al., 2014). Therefore, this study expects CSOEs to take more responsibility than LSOEs to achieve the national goal of carbon neutrality and to face stronger negative market reactions to the carbon neutrality commitment.

H2: The negative market reaction to the carbon neutrality commitment is stronger for CSOEs than LSOEs.

The Chinese government promotes CSR as a desirable attribute (Yin and Zhang, 2012), especially for SOEs (Li and Guo, 2022). Corporate environmental performance, a non-financial indicator, is included in appraisals of SOE managers' performance (Gao, 2009). In response to strong government intervention, SOEs perform well in CSR activities by increasing employment to maintain social stability (Liu et al., 2022), engaging in philanthropic activities to support the country's pro-social objectives (C. Qian et al., 2015) and responding positively to the government's environmental policies targeting the achievement of green and sustainable development (Guo et al., 2020). Consequently, SOEs have better CSR performance and higher CSR ratings than do non-SOEs (Li and Zhang, 2010). This study expects SOEs with good CSR performance to take the lead in cutting carbon emissions in response to calls from the central government, leading to a strong negative market reaction to the carbon neutrality commitment.

H3: The negative market reaction to carbon neutrality commitment is stronger for SOEs with good CSR performance than for SOEs with poor CSR performance.

Fig. 4.1 provides the framework for hypothesis development.

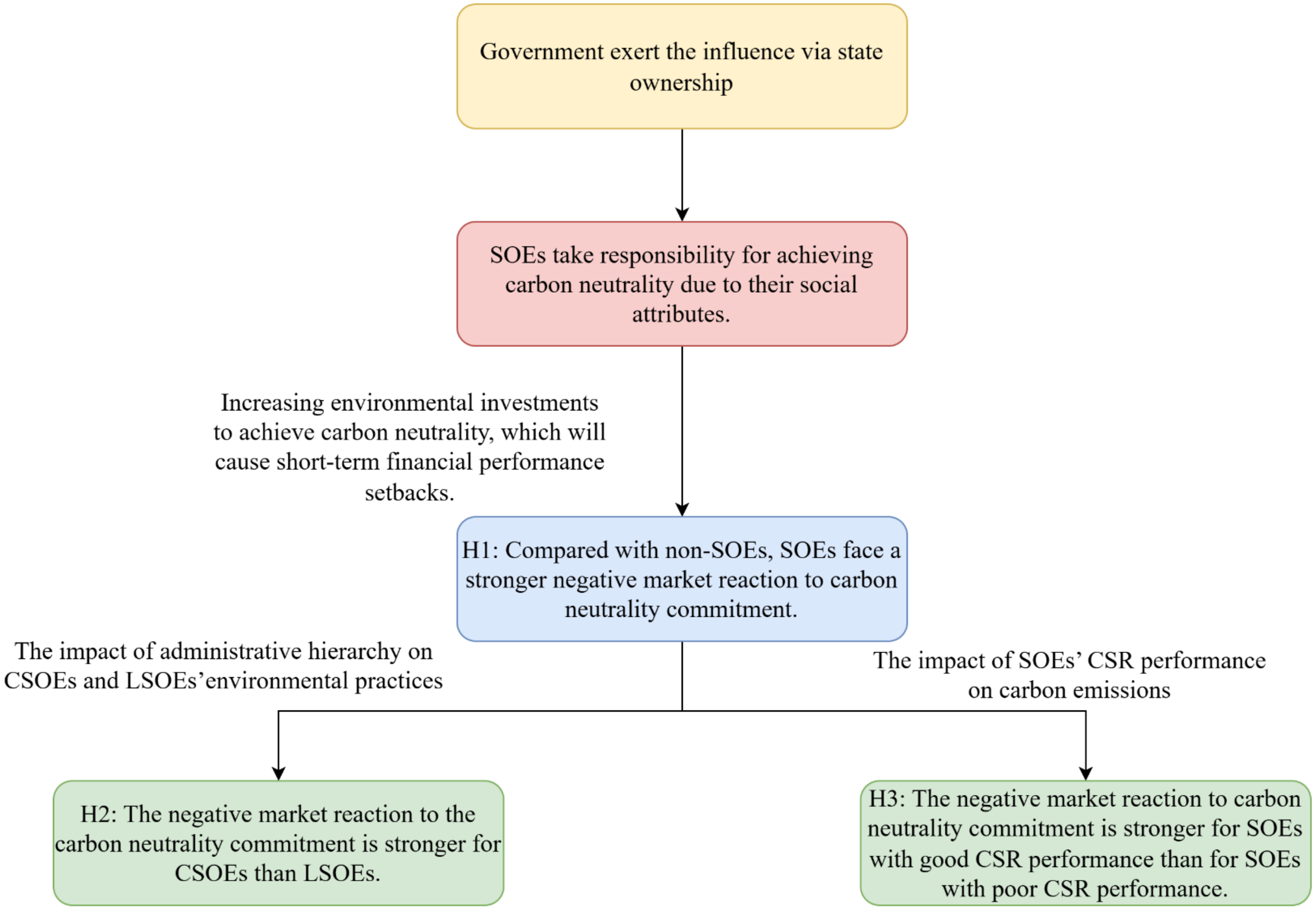

Figure 4.1 SOEs are more responsible for carbon neutrality

4.3. Sample, variables and methodology

4.3.1. Sample and data

The research sample contains all listed firms from Shanghai and Shenzhen A-shares markets in China. This study removes firms that lack sufficient daily return data to calculate market reactions to the announcement of the carbon neutrality commitment. The final sample comprises 2,792 companies. Daily stock return and financial statement data are retrieved from the China Stock Market & Accounting Research Database (CSMAR). Market return, risk-free rate, size factor, value factor and turnover factor data are collected from (Liu et al., 2019).

This study divides the sample firms into SOEs and non-SOEs. The controlling shareholders of SOEs are the central or local state asset management bureau or government departments. SOEs include both CSOEs and LSOEs. CSOEs are controlled by the central asset management bureau or central government departments, while LSOEs are supervised by the local state asset management bureau or other local state departments. State ownership data are collected from the Wind database. This study measures the CSR performance of listed firms according to the CSR scores obtained from the Hexun website (www.hexun.com).

4.3.2. Methodology and model setting

This study first uses the event study method to calculate the cumulative abnormal returns (CARs) and thus capture the market reactions of listed firms in research sample to the government's carbon neutrality commitment. This study compares the CARs between SOEs and non-SOEs, and between LSOEs, CSOEs and non-SOEs. Next, this study conducts a multivariate analysis to investigate the impact of state ownership on market reactions.

Event study

The event study method is widely employed to gauge market reactions (e.g., Tang and Zhang, 2020; Flammer, 2021). On 22 September 2020, China pledged to the world that it expects to achieve carbon neutrality by 2060. This was China's first formal proposal of a carbon-neutral goal. We therefore choose 22 September 2020 as the event day in the analysis.[4] Following Pevzner et al. (2015), a two-day event window around the announcement, which was made after the trading hour on day 0, is selected to calculate the CARs surrounding the event. The market and market-adjusted models are used to compute the two-day CARs over the (0, 1) event window. Following Xie et al. (2022), this study adopts a 200-day estimation window to run the models, which ranges from trading day -210 through day -11 before the event date.

To calculate the CARs, this study runs the following market model in the estimation window for each listed firm in research sample:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \epsilon_{i,t} \tag{4.1}$$

where $R_{i,t}$ is the daily stock return and $R_{m,t}$ is the daily market return in the estimation window. α_i is a constant, and β_i is the beta coefficient; both parameters are estimated from the regression. $\epsilon_{i,t}$is the error term. The estimated parameters $\hat{\alpha}_i$ and $\hat{\beta}_i$ are used to compute the daily expected return. The abnormal return (AR) during the event window can be derived from the difference between the realised return and the expected return from model (1), as follows:

$$AR_{i,t} = R_{i,t} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}) \quad t \in [t_1, t_2] \tag{4.2}$$

where $\hat{\alpha}_i$ and $\hat{\beta}_i$ are estimated by ordinary least squares regression. t_1 and t_2 represent the beginning and end of the event window, respectively.

This study also uses the market-adjusted model to calculate the AR. In this model, the observed return of the reference market on day *t*, $R_{m,t}$, is subtracted from the return $R_{i,t}$ of observation *i* on day *t*. The AR is computed as follows:

$$AR_{i,t} = R_{i,t} - R_{m,t} \quad t \in [t_1, t_2] \tag{4.3}$$

[4] Since announcing its first carbon neutrality commitment, the Chinese government has successively proposed carbon neutrality commitments at major conferences. However, as these subsequent commitments are accompanied by specific policy support, it is impossible to detect a pure market reaction. Therefore, this paper only uses the time of the first carbon neutrality commitment as the event date.

CAR represents the sum of an enterprise's abnormal returns during the event window:

$$CAR_{i,t} = \sum AR_{i,t} \quad t \in [t_1, t_2] \tag{4.4}$$

Multivariate analysis

This study uses the following regression model to compare the CARs of SOEs and non-SOEs:

$$CAR = \beta_0 + \beta_1 SOE + \beta_i Control + Industry\ FE + \epsilon_{i,t} \tag{4.5}$$

CAR is calculated using the market model (*CAR1*) or market-adjusted model (*CAR2*). *SOE*, the key independent variable, equals one if a firm is owned by the state or a state-controlled institution, and zero otherwise. This study controls for a set of firm-level variables, including the cumulative stock return over the previous 90 trading days (*MOM*), return on assets (*ROA*), log of market value of equity (*LNMV*), book-to-market ratio (*BM*), leverage ratio (*LEV*) and capital expenditure ratio (*CAPEX*). These financial variables are derived from firms' 2019 financial statements and thus lagged by one year and are winsorised at the 1% and 99% levels. Industry fixed effect is included in the regression to control for unobservable common factors at the industry level. Some studies highlight that there is provincial heterogeneity when it comes to environmental quality in China (Andersson et al., 2018; Shahbaz et al., 2020). Therefore, the provincial fixed effect is included in the regression to control for unobservable common factors at the provincial level. β_1 is the key coefficient, and a negative and significant coefficient suggests that SOEs take the lead in achieving carbon neutrality commitments and hence have the strongest negative market reactions to the event commitment.

This study tests whether CSOEs are more responsible for achieving carbon neutrality than LSOEs. The following regression is applied:

$$CAR = \beta_0 + \beta_1 CSOE + \beta_2 LSOE + \beta_i Control + Industry\ FE + \epsilon_{i,t} \tag{4.6}$$

where *CSOE* is a dummy variable equal to one if a company is under the central state or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. The control variables remain consistent with those in Eq. (5). This study also includes industry fixed effects in this regression. The definitions of these variables are in Appendix B1.

4.4. Empirical results

4.4.1. Descriptive statistics

Table 4.1 lists the descriptive statistics of the variables used in the empirical studies. The average two-day *CAR1* value is -0.54%, while that of *CAR2* is -0.43%. In the sample, 39% of the total firms are SOEs; LSOEs account for 27% of the total firms, while CSOEs account for 13%. The average CSR score (*CSR*) is 19.66. The range of Tobin Q is 0.50 and 11.60. The average carbon intensity is 0.38. In the sample, *MOM* ranges from -78.3% to 132.6%. The average *LEV* is 0.46. On average, *CAPEX* accounts for 4.2% of the company's total assets. The average *ROA* is 0.03, and the mean *BM* is 0.59. The average *LNMV* is about 15.83. The average ratio of sale growth is 0.17, and the average log of firm age is 2.36.

Table 4.1 Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min	Max
CAR1	2,792	-0.54	2.31	-6.90	8.02
CAR2	2,792	-0.43	2.39	-6.92	8.87
SOE	2,792	0.39	0.49	0	1
LSOE	2,792	0.27	0.44	0	1
CSOE	2,792	0.13	0.33	0	1
CSR	2,757	19.66	9.39	-17.18	41.01
MOM	2,784	0.20	0.22	-0.78	1.33
TOBINQ	13,811	1.97	1.49	0.50	11.60
Carbon Intensity	8,146	0.38	1.93	0	126.22
LEV	13,812	0.46	0.21	0.06	1
CAPEX	2,784	0.04	0.04	0	0.20
ROA	13,812	0.03	0.08	-0.37	0.21
BM	13,768	0.59	0.58	-0.05	18.12
LNMV	13,768	15.83	1.12	13.23	21.67
SALEGROWTH	13,441	0.17	0.45	-0.70	3.27
AGE	13,771	2.36	0.84	0	3.47

This table reports the summary statistics. Cumulative abnormal returns (CAR1 and CAR2) are in the percentage. The SOE, LSOE and CSOE are the corporate ownership characteristics. Firm level variables also include the corporate social responsibility score (CSR), past stock return in the last 90 trading days (MOM), leverage ratio (LEV), capital expenditure ratio (CAPEX), return of assets (ROA), book to market (BM), market value of equity (LNMV), firm Tobin Q (TOBINQ), firm sale growth (SALEGROWTH), firm age (AGE) and firm carbon intensity (Carbon Intensity). Variable definitions are in the Appendix B1.

4.4.2. State ownership and market reaction to the carbon neutrality commitment

Table 4.2 lists the mean CARs for all listed firms in the sample and for SOEs and non-SOEs. The CARs are negative and significant at the 1% level for the full sample, indicating that the carbon neutrality commitment is creditable and expected to negatively affect the financial performance of listed firms in China. The main argument is that SOEs are more responsible for achieving the carbon neutrality commitment than are non-SOEs. For SOEs, *CAR1* and *CAR2* are -0.75% and -0.68%, respectively, and both are significant at 1% level; the corresponding values for non-SOEs are -0.40% and -0.28%, respectively. The magnitudes of the market reactions in SOEs are almost twice those in non-SOEs. The differences in *CAR1* and *CAR2* between SOEs and non-SOEs are significant at the 1% level. These results indicate that SOEs face a stronger negative market reaction to the carbon neutrality commitment than do non-SOEs, which supports H1.

Table 4.2 CARs of full sample, SOEs and non-SOEs

	Obs.	CAR1	t-stat	CAR2	t-stat
Full sample	2,792	-0.54***	(-12.27)	-0.44***	(-9.60)
SOEs	1,094	-0.75***	(-12.03)	-0.68***	(-10.59)
Non-SOEs	1,698	-0.40***	(-6.70)	-0.28***	(-4.49)
Difference (SOEs - non-SOEs)		-0.36***	(-3.99)	-0.40***	(-4.37)

This table reports the CARs for the market responding to the carbon neutrality commitment with different ownership characteristics if the firm is SOE. This study calculates CARs using the market model and market-adjusted model. CARs are in the percentage. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. *** p<0.01, ** p<0.05, * p<0.10.

Table 4.3 provides the regression results based on Eq. (4.5). Columns (1) and (2) report the CARs obtained using the market model and market-adjusted model, respectively. The coefficients of *SOE* are -0.23 and -0.24, respectively, and are significant at the 5% level. These findings indicate that SOEs face a more negative market reaction to the carbon neutrality commitment than do non-SOEs. The results again support H1. This finding is consistent with Guo et al. (2020), who find that Chinese SOEs are actively engaged in government environmental policies, leading to a loss of their market value. Column (2) also shows that the market reaction to the carbon neutrality commitment is positively related to *MOM* and *ROA*, but negatively related to *BM*.

Table 4.3 SOEs and market reaction to carbon neutrality commitment

	(1) CAR1	(2) CAR2
SOE	-0.20*	-0.19*
	(-1.95)	(-1.93)
MOM	0.50*	-0.17
	(1.76)	(-0.62)
LEV	-0.52**	-0.52**
	(-2.02)	(-2.07)
CAPEX	0.24	-0.10
	(0.19)	(-0.08)
ROA	0.95*	0.69
	(1.86)	(1.40)
BM	-0.27*	-0.27*
	(-1.81)	(-1.93)
LNMV	-0.06	-0.03
	(-1.26)	(-0.72)
Constant	0.88	0.50
	(1.20)	(0.69)
Industry Fixed Effect	Yes	Yes
Provincial Fixed Effect	Yes	Yes
Observations	2784	2784
R-squared	0.0520	0.0497

This table provides the results from multivariate analysis for the state ownership and market reaction. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, and LNMV. The industry and provincial fixed effect are included in this sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.4.3. CSOEs, LSOEs and market reaction to the carbon neutrality commitment

This study next investigates whether CSOEs and LSOEs may behave differently in the pursuit of carbon neutrality and hence experience different market reactions to the carbon neutrality commitment. Table 4.4 shows that for CSOEs, the average *CAR1* and *CAR2* are -0.96% and -0.93%, respectively, while the corresponding values for LSOEs are only -0.65% and -0.56%, respectively. In other words, the market reactions to the carbon neutrality commitment are significantly more negative for CSOEs than for LSOEs. These findings support H2, which hypothesises that the negative market reaction to the carbon neutrality commitment is more substantial for CSOEs than for LSOEs, probably because the former must assume greater responsibility for reducing carbon emissions. The results also indicate that the market reactions for both CSOEs and LSOEs are more negative than those for non-SOEs.

Table 4.4 CARs of CSOEs and LSOEs

Variables	Obs.	CAR1	t-stat	CAR2	t-stat
CSOEs	354	-0.96***	(-9.67)	-0.93***	(-9.14)
LSOEs	740	-0.65***	(-8.25)	-0.56***	(-6.90)
Non-SOEs	1,698	-0.40***	(-6.7)	-0.28***	(-4.49)
Difference (CSOEs - LSOEs)		-0.31**	(-2.32)	-0.37***	(-2.69)
Difference (CSOEs - non-SOEs)		-0.56***	(-4.11)	-0.65***	(-4.58)
Difference (LSOEs - non-SOEs)		-0.25**	(-2.47)	-0.28***	(-2.65)

This table reports the CARs for the market responding to the carbon neutrality commitment with different ownership characteristics if the firm is CSOE or LSOE. This study calculates CARs using the market model and market-adjusted model. CARs are in the percentage. *CSOE* is a dummy variable equal to one if a company is under the central state or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. *** p<0.01, ** p<0.05, * p<0.10.

This research employs multivariate analysis based on Eq. (4.6) to further test H2. Table 4.5 shows the cross-sectional regression results for the different administration affiliations. Columns (1) and (2) display the data for *CAR1* and *CAR2*, respectively. The coefficients of *CSOE* are -0.39 and -0.40, respectively, which are negative and significant at the 1% level. The coefficient of *LSOE* is -0.16 in both columns (1) and (2) and is negative but nonsignificant in both columns. These findings indicate that the negative market reaction to the carbon neutrality commitment is much stronger for CSOEs than for LSOEs, in comparison with market reactions for non-SOEs (control group). These results are consistent with the findings of Liang and Ma (2020), who have shown that CSOEs are more likely than LSOEs to be assigned tasks related to reducing carbon emissions. Consequently, this increased burden of responsibility to reduce carbon emissions often leads to poorer financial performance for CSOEs. Hence, the findings provide further support for H2.

Table 4.5 Central SOEs, local SOEs and market reaction to carbon neutrality commitment

	(1)	(2)
	CAR1	CAR2
CSOE	-0.47***	-0.42***
	(-3.44)	(-3.21)
LSOE	-0.09	-0.09
	(-0.77)	(-0.84)
MOM	0.51*	-0.17
	(1.77)	(-0.61)
LEV	-0.54**	-0.54**
	(-2.09)	(-2.12)
CAPEX	0.22	-0.12
	(0.18)	(-0.10)
ROA	0.92*	0.67
	(1.79)	(1.33)
BM	-0.26*	-0.26*
	(-1.75)	(-1.87)
LNMV	-0.04	-0.02
	(-0.91)	(-0.41)
Constant	0.63	0.28
	(0.84)	(0.38)
Industry Fixed Effect	Yes	Yes

Provincial Fixed Effect	Yes	Yes
Observations	2784	2784
R-squared	0.0539	0.0512

This table provides the results from multivariate analysis for the different state administration affiliations and market reactions. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. *CSOE* is a dummy variable equal to one if a company is under the central state or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, and LNMV. The industry and provincial fixed effect are included in this sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.4.4. CSR, SOEs and market reaction to the carbon neutrality commitment

In this section, this study tests whether CSR drives SOEs to respond more strongly than non-SOEs to the carbon neutrality commitment. In China, CSR is primarily initiated by the government (Marquis and Qian, 2014). SOEs are often considered pioneers in the implementation of government policies and are more likely than non-SOEs to practise CSR under government pressure (Li and Guo, 2022). In 2009, the SASAC required all SOEs to publish a CSR or sustainability report within three years and began to incorporate CSR practices into its SOE annual assessment system. This study thus expects that SOEs with better CSR performance are more accountable for carbon neutrality than other enterprises and hence experience more negative market reactions to the carbon neutrality commitment.

Table 4.6 reports the results of the analysis of market reactions to the carbon neutrality commitment among firms with high and low CSR performance. This study separates research sample into high CSR score and the low CSR score sub-samples according to the mean CSR score of the sample. The results shows that the coefficient of *SOE* is significant and negative only in the high CSR score sub-sample. The corresponding coefficient in the low CSR score group is negative but nonsignificant. This study uses the chi-square test to reveal a statistically significant difference between the coefficients of *SOE* in the high and low CSR score groups. These findings indicate that for SOEs, CSR drives them to fulfil the government's vision of achieving carbon neutrality. Consistent with Zhang (2017), SOEs with greater CSR are more likely than other SOEs to respond to a call from the government.

Table 4.6 Social responsibility, SOEs and market reaction to carbon neutrality commitment

	High CSR Score		Low CSR Score	
	(1)	(2)	(3)	(4)
	CAR1	CAR2	CAR1	CAR2
SOE	-0.24*	-0.24*	0.04	0.03
	(-1.74)	(-1.77)	(0.26)	(0.18)
MOM	0.91**	0.24	0.23	-0.44
	(2.35)	(0.63)	(0.53)	(-1.03)
LEV	-0.38	-0.46	0.10	0.10
	(-0.89)	(-1.10)	(0.28)	(0.26)
CAPEX	-0.32	-0.61	2.56	2.59
	(-0.20)	(-0.39)	(1.24)	(1.30)
ROA	5.48***	4.85**	-0.07	-0.24
	(2.74)	(2.48)	(-0.11)	(-0.38)
BM	-0.06	-0.06	-0.41*	-0.40*
	(-0.69)	(-0.69)	(-1.91)	(-1.92)
LNMV	-0.05	-0.03	-0.29***	-0.21**
	(-0.79)	(-0.47)	(-2.87)	(-2.08)
Constant	0.28	0.04	3.86**	2.68*
	(0.30)	(0.05)	(2.57)	(1.78)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes
Observations	1604	1604	1145	1145
R-squared	0.1817	0.1622	0.1458	0.1443
Coef. of SOE in High CSR Score group= Coef. of SOE in low CSR Score group	p=0.000	p=0.000		

This table provides the results from multivariate analysis for the state ownership and market reaction to the carbon neutrality commitment with different CSR score. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, and LNMV. The industry and provincial fixed effect are included in this sample. *** p<0.01, ** p<0.05, * p<0.10.

Therefore, this study examines the effect of CSR separately on CSOEs and LSOEs' compliance with the government's carbon neutrality commitments. This study uses non-SOEs as the control group to capture the market reaction and thus determine which group is most responsible for achieving carbon neutrality.

Table 4.7 shows the results of the impact of CSR on LSOEs, CSOEs and the market reaction to carbon neutrality. The results show that only CSOEs with a high CSR score experience a more negative market reaction than do non-SOEs. The coefficients of *LSOE* are nonsignificant in both the high CSR score and low CSR score sub-samples. In 2008, the SASAC required CSOEs to effectively fulfil their environmental responsibilities by increasing environmental investments, implementing cleaner production and reducing pollutant emissions. Since then, CSOEs increasingly have assumed responsibility for environmental protection (Luo et al., 2016). Results further show that CSOEs with high CSR scores are more likely than other firms to exert real effort to achieve carbon neutrality. Overall, the results in this section support H3, which states that SOEs with a high level of responsibility experience more negative reactions to the carbon neutrality commitment than non-SOEs because they are given more tasks to reduce carbon emissions.

Table 4.7 Social responsibility, LSOEs, CSOEs and market reaction to carbon neutrality commitment

	High CSR Score		Low CSR Score	
	(1)	(2)	(3)	(4)
	CAR1	CAR2	CAR1	CAR2
CSOE	-0.34*	-0.31*	-0.23	-0.21
	(-1.95)	(-1.85)	(-1.04)	(-0.97)
LSOE	-0.15	-0.15	0.21	0.18
	(-0.95)	(-1.00)	(1.26)	(1.10)
MOM	0.73*	0.06	0.01	-0.63
	(1.90)	(0.16)	(0.03)	(-1.50)
LEV	-0.84**	-0.89**	-0.02	0.01
	(-2.04)	(-2.23)	(-0.05)	(0.03)
CAPEX	-1.43	-1.87	3.30*	3.15*
	(-0.92)	(-1.24)	(1.69)	(1.68)
ROA	5.66***	4.85**	-0.07	-0.17
	(2.89)	(2.57)	(-0.12)	(-0.31)

BM	-0.11	-0.12	-0.34*	-0.35*
	(-1.06)	(-1.23)	(-1.77)	(-1.89)
LNMV	-0.03	-0.01	-0.32***	-0.23**
	(-0.44)	(-0.14)	(-3.41)	(-2.48)
Constant	0.23	0.03	4.26***	3.01**
	(0.24)	(0.03)	(3.09)	(2.17)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes
Observations	1604	1604	1145	1145
R-squared	0.0854	0.0774	0.0854	0.0856

This table provides the results from multivariate analysis for the different state administration affiliations and market reactions to the carbon neutrality commitment with different CSR score. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. *CSOE* is a dummy variable equal to one if a company is under the central state or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, and LNMV. The industry and provincial fixed effect are included in this sample. *** p<0.01, ** p<0.05, * p<0.10.

4.4.5. Robustness tests

Different estimation model

As the first robustness test, we use a four-factor model proposed by Liu et al. (2019) to construct an alternative measure of CAR (*CAR3*). The model includes market, size, value and sentiment factors and is defined as follows:

$$R_{i,t} = \alpha_i + \beta_{MKT}MKT_t + \beta_{VMG}VMG_t + \beta_{SMB}SMB_t + \beta_{PMO}PMO_t + \in_t \quad (4.7)$$

where MKT_t is the excess market return, VMG_t is the value factor, SMB_t is the size factor and PMO_t is the sentiment factor based on abnormal turnover. Therefore, $AR_{i,t}$ can be calculated for each stock using the following formula:

$$AR_{i,t} = R_{i,t} - (\alpha_2 + \beta_{MKT}MKT_t + +\beta_{VMG}VMG_t + \beta_{SMB}SMB_t + \beta_{PMO}PMO_t) \quad (4.8)$$

The results of robustness testing using the alternative CARs are presented in Table 4.8. For the full sample, *CAR* is -0.29% and statistically significant at the 1% level.

Similar to the results based on *CAR1* and *CAR2*, this study finds in the analysis based on *CAR3* that the market reactions are more negative for SOEs than for non-SOEs in the robustness test. CSOEs also experience more negative market reactions than do LSOEs. The main results are robust to the use of an alternative model to calculate CARs.

Table 4.8 Alternative benchmarks for abnormal return for the market reaction

	Obs.	CAR3	t-stat
Full sample	2,792	-0.29***	(-6.08)
SOEs	1,094	-0.47***	(-6.95)
Non-SOEs	1,698	-0.17***	(-2.64)
Difference (SOEs - non-SOEs)		-0.30***	(-3.13)
CSOEs	354	-0.80***	(-7.48)
LSOEs	740	-0.31***	(-3.65)
Difference (CSOEs - LSOEs)		-0.49***	(-3.40)
Difference (CSOEs - non-SOEs)		-0.63***	(-4.26)
Difference (LSOEs - non-SOEs)		-0.14	(-1.28)

This table provides the results for the state ownership and market reaction to the carbon neutrality commitment. CAR is the short-term market reaction, calculated by a four-factor model proposed by Liu et al. (2019). CARs are in the percentage. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. *CSOE* is a dummy variable equal to one if a company is controlled by the central government or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Different event window

This study also conducts additional analyses using different event window. Table 4.9 provides the results from a robustness test based on event windows of days (-5, 10), (0,10) and (0,15). The results show that the CARs increase in magnitude when this study uses a longer event window. However, what remains consistent is the finding that SOEs face more negative market reactions compared to non-SOEs. The results thus appear to be robust to analysis with a different event window. In addition to the event window extension, this study also evaluated the robustness of the results by using an estimation window ranging from day -150 to day -50, as suggested by Cheng et al.

(2021), The findings remain consistent even with this different estimation window, further confirming the robustness of the results.

Table 4.9 Alternative event time windows for the market reaction

	Event window	Obs.	CAR1	t-stat	CAR2	t-stat
Full sample	(-5,10)	2,792	-1.57***	(-10.83)	-2.35***	(-16.91)
SOEs		1,094	-2.06***	(-10.40)	-2.44***	(-12.77)
Non-SOEs		1,698	-1.24***	(-6.23)	-2.30***	(-11.92)
Difference (SOEs - non-SOEs)			-0.82***	(-2.77)	-0.14	(-0.49)
Full sample	(0,10)	2,792	-1.49***	(-12.63)	-1.98***	(-17.40)
SOEs		1,094	-2.32***	(-15.00)	-2.54***	(-16.54)
Non-SOEs		1,698	-0.95***	(-5.77)	-1.61***	(-10.22)
Difference (SOEs - non-SOEs)			-1.37***	(-5.72)	-0.93***	(-4.00)
Full sample	(0,15)	2,792	-2.67***	(-19.48)	-3.31***	(-23.41)
SOEs		1,094	-3.46***	(-18.72)	-3.70***	(-18.65)
Non-SOEs		1,698	-2.17***	(-11.37)	-3.07***	(-15.78)
Difference (SOEs - non-SOEs)			-1.29***	(-4.59)	-0.63**	(-2.16)

This table reports the CARs for the market responding to the carbon neutrality commitment with different ownership characteristics. This study calculates CARs using the market model and market-adjusted model and multiple CARs by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Event windows are (-5, 10), (0,10) and (0,15). The estimation window starts from 210 trading days to 10 trading days before the announcement date. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

This study also uses the buy and holder abnormal return (BHAR) to measure the long-term market valuation. BHAR is the buy-hold abnormal return in 1 month after the carbon neutrality commitment, calculated by the difference of cumulative raw returns and the corresponding cumulative expected return. These analyses allowed to test the long-term market reaction for the carbon neutrality commitment with different ownership characteristics, and the results are presented in Table 4.10 and Table 4.11.

Table 4.10 reports the mean BHAR for all in the sample and for SOEs and non-SOEs. The BHAR is negative and significant at the 1% level for the full sample. The BHAR of SOEs is -3.69% and significant at 1% level, while the BHAR of non-SOEs is -2.41% and significant at 1% level. The difference in BHAR between the SOEs and non-SOEs is negative and significant at 1% level. Table 4.11 provides the regression result for BHAR. The coefficient of SOE is -1.91% and significant at 1% level. These findings indicate that the negative market reaction to the carbon neutrality commitment is much stronger for SOEs than for non-SOEs. Therefore, these results support the H1 that the SOEs face a stronger negative market reaction to the carbon neutrality commitment than do non-SOEs.

Table 4.10 BHAR of full sample, SOEs and non-SOEs

	Obs.	BHAR	t-stat
Full sample	2,792	-2.91***	(-12.39)
SOEs	1,094	-3.69***	(-12.64)
Non-SOEs	1,698	-2.41***	(-7.15)
Difference (SOEs - non-SOEs)		-1.29***	(-2.68)

This table report the BHAR for the market responding to the carbon neutrality commitment with different ownership characteristics. BHAR is the buy-hold abnormal return in 1 month after the carbon neutrality commitment, calculated by the difference of cumulative raw returns and the corresponding cumulative expected return. The BHAR is multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

Table 4.11 SOEs and market reaction to carbon neutrality commitment

	(1)
	BHAR
SOE	-1.91***
	(-3.95)
Control	Yes
Industry Fixed Effect	Yes
Provincial Fixed Effect	Yes
Observations	2784
R-squared	0.1056

This table provides the results from multivariate analysis for the state ownership and market reaction. BHAR is the buy-hold abnormal return in 1 month after the carbon neutrality commitment, calculated by the difference of cumulative raw returns and the corresponding cumulative expected return. BHAR are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, and LNMV. Industry and provincial fixed effect are included in this sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Different regions

This research considers the geographical distribution of SOEs in China. Historically, the carbon-intensive industries have been concentrated in the central and western regions. These regions have been the major contributors to China's carbon emissions due to the presence of industries such as coal mining and heavy manufacturing (Zhu et al., 2014). The eastern region of China has a different industrial profile, with a greater emphasis on non-carbon-intensive industries. SOEs in the eastern region are predominantly involved in sectors such as technology, finance, and services, which have a lower carbon footprint compared to industries in the central and western regions (Zhao et al., 2022). Table 4.12 provides evidence to support this differentiation between the regions. It showcases that SOEs in the central and western regions experience significantly more negative market reactions compared to their counterparts in the eastern region. This suggests that investors are more pessimistic about the financial performance and prospects of carbon-intensive SOEs located in the central and western regions. Furthermore, the comparison between SOEs and non-SOEs in both eastern and non-eastern regions reveal that SOEs face consistently more negative market reactions regardless of the region. Therefore, the main results regarding SOEs are robust to analyses stratified by region.

Table 4.12 CAR of SOEs and non-SOEs in different regions

Variables	Obs.	CAR1	t-stat	CAR2	t-stat
SOEs in the eastern region	675	-0.64***	(-7.90)	-0.56***	(-6.71)
Non-SOEs in the eastern region	1,262	-0.40***	(-5.87)	-0.29***	(-4.08)
Difference (SOEs and non-SOEs)		-0.24**	(-2.20)	-0.27**	(-2.40)
SOEs in the central and western regions	419	-0.94***	(-9.52)	-0.87***	(-8.76)
Non-SOEs in the central and western regions	436	-0.40***	(-3.24)	-0.25*	(-1.94)
Difference (SOEs and non-SOEs)		-0.54***	(-3.42)	-0.62***	(-3.87)

This table provides the results for the state ownership and market reaction to the carbon neutrality commitment in different regions. CARs are in the percentage. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Market response to cross listed SOEs and non-cross-listed SOEs

Previous studies have been consistently demonstrated that cross-listed firms perform better on CSR than their domestically listed counterparts (Boubakri et al., 2016; Del Bosco and Misani, 2016). In this section, this study examines the differences in market reaction to carbon neutrality commitments between cross-listed SOEs and non-cross-listed SOEs. Cross-listed firms are firms that listed in Chinese mainland stock exchanges (Shenzhen and Shanghai stock exchanges) and in Hong Kong stock exchange. Non-cross-listed SOEs are firms that only listed in Chinese mainland stock exchanges. This study matches cross-listed and non-cross-listed SOEs operating in the same industry to ensure comparability. In the sample, the average CSR score for cross-listed SOEs is 23.53, while the average for non-cross-listed SOEs is 20.50. Table 4.13 presents a comparison of the market reactions of both cross-listed and non-cross-listed SOEs. The results show that SOEs listed on both the A-share market and the Hong Kong Stock Exchange exhibited more pronounced negative market reactions compared to SOEs solely listed on the A-share market. This finding suggests that cross-listed SOEs, known for their superior CSR performance, experience more negative market reactions in response to carbon neutrality commitments than non-cross-listed SOEs.

Table 4.13 CARs of cross-listed SOEs and non-cross- listed SOEs

	Obs.	CAR1	t-stat	CAR2	t-stat
Full sample	813	-0.69***	(-9.52)	-0.77***	(-12.03)
AH-SOEs	86	-0.96***	(-5.09)	-0.96***	(-5.16)
Non-AH-SOEs	727	-0.66***	(-8.46)	-0.74***	(-11.14)
Difference (AH-SOEs - non-AH-SOEs)		-0.30	(-1.26)	-0.22	(-0.93)

This table reports the CARs for the market responding to the carbon neutrality commitment with cross-list SOEs and non-cross-list SOEs. This study calculates CARs using the market model and market-adjusted model. CARs are multiplied by 100. The AH-SOE is a dummy variable equal to one if SOEs are both listed in Shenzhen and Shanghai A-share market and Hong Kong Stock Exchanges, and zero otherwise. The non-AH-SOEs is a dummy variable equal to one if SOEs are only listed in A-share market, and zero otherwise. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Market response to SOEs and QFIIs-owned firms

This research also investigates market reactions to SOEs, and firms owned by qualified foreign institutional investors (QFIIs)[5]. This study matches SOEs and QFIIs-owned firms operating in the same industry to ensure comparability. Table 4.14 provides the results of the comparison of the market reactions between SOEs and QFIIs-owned firms. In the market model, the market reaction of QFIIs-owned firms estimated by the market model is 0.09% but nonsignificant. In the market-adjusted model, CARs from QFIIs-owned firms are -0.01%, a slight negative but non-significant. While the CARs for SOEs are both negative and significant. This result shows that SOEs have a greater negative market reaction than QFIIs-owned firms. Previous studies highlight that QFIIs contribute to reducing firms' greenhouse gas emissions and improving firm environmental performance (Dyck et al., 2019; Ren et al., 2023). Due to their favourable environmental performance and lower greenhouse gas emissions, QFII-controlled firms are less responsible for achieving carbon neutrality commitments. Therefore, SOEs are more likely to experience pronounced and significant negative market reactions than firms controlled by QFIIs.

Table 4.14 CARs of SOEs and QFIIs-owned firms

	Obs.	CAR1	t-stat	CAR2	t-stat
Full sample	978	-0.50***	(-6.94)	-0.59***	(-8.40)
SOEs	832	-0.60***	(-8.01)	-0.69***	(-9.40)
QFIIs-owned firms	146	0.09	(0.41)	-0.01	(-0.04)
Difference (SOEs -QFIIs-owned firms)		-0.69***	(-3.44)	-0.68***	(-3.48)

This table reports the CARs for the market responding to the carbon neutrality commitment with SOEs and QFIIs-owned firms. This study calculates CARs using the market model and market-adjusted model. CARs are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. The QFIIs-owned firms are firms that are owned by the qualified foreign institutional investor. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. *** p<0.01, ** p<0.05, * p<0.10.

[5] The term QFIIs refers to qualified foreign institutional investors who rank among the top ten largest investors in a company. These firms are normally non-SOEs.

Alternative channel: low carbon efficiency

The majority of SOEs are located in carbon-intensive industries such as construction, iron and steel, non-ferrous metals and chemicals (Wang et al., 2019) Therefore, the main results may be driven by the low carbon efficiency of firms in these industries rather than by the responsibility placed on SOEs to achieve carbon neutrality. To differentiate these possibilities, this study divides the sample into carbon-intensive and non-carbon-intensive industries and separately examine the market reactions experienced by SOEs in both sub-samples. This study defines carbon-intensive industries as the eight high-energy-consuming and high-emission industries specified by the State Council: power generation, petrochemicals, chemicals, building materials, steel, non-ferrous metals, paper and civil aviation. According to the classification, 291 SOEs in the sample are considered carbon-intensive industries, accounting for approximately 26.60% of all included SOEs.

Table 4.15 displays the results of the comparison of the market reactions between SOEs and non-SOEs in carbon-intensive and non-carbon-intensive industries. Consistent with expectations, the findings reveal that SOEs operating in carbon-intensive industries experience more pronounced negative market reactions compared to their counterparts in non-carbon-intensive industries. This outcome is reasonable given the higher carbon emissions associated with carbon-intensive industries. However, SOEs in both industry sub-samples face significantly negative market reactions compared with those faced by non-SOEs. This observation suggests that the main results are not driven by SOEs with low carbon efficiency. These results highlight the broader expectations and scrutiny that the marketplaces on all SOEs, regardless of industry classification, when it comes to addressing carbon emissions. The negative market reactions observed across both subsamples suggest that investors and stakeholders attribute a higher level of responsibility and anticipate more substantial efforts from SOEs, regardless of their industry, in contributing towards carbon neutrality.

In the unreported results, this study includes the scope 1 emissions intensity as control variable in the models of Equations (4.5) and (4.6) and rerun the tests for main results. Previous studies (e.g., Bolton and Kacperczyk, 2023) use carbon emissions data from Trucost to calculate firms' carbon emissions intensity. However, the Trucost emission data only cover 1,508 listed firms in China, which accounted for 54.01% of the research sample. Despite this limitation, this study includes scope 1 emissions in the model to test the hypotheses, and the results remain robust (Appendix B2). In sum, it is very unlikely that the stronger negative market reactions to carbon neutrality commitment from SOEs are driven by high carbon emissions intensity in SOEs.

Table 4.15 CAR of SOEs and non-SOEs in different industries

Variables	Obs.	CAR1	t-stat	CAR2	t-stat
SOEs in the Carbon intensive industries	291	-1.16***	(-9.91)	-1.10***	(-9.22)
SOEs in the non-intensive industries	803	-0.61***	(-8.27)	-0.53***	(-7.00)
Difference (carbon intensive and non-intensive industries)		-0.55***	(-3.91)	-0.67***	(-3.98)
SOEs in the Carbon intensive industries	291	-1.16***	(-9.91)	-1.10***	(-9.22)
Non-SOEs in the Carbon intensive industries	380	-0.79***	(-6.16)	-0.67***	(-5.15)
Difference (SOEs and non-SOEs)		-0.37**	(-2.03)	-0.43**	(-2.34)
SOEs in the non-intensive industries	803	-0.61***	(-8.27)	-0.53***	(-7.00)
Non-SOEs in the non-intensive industries	1,318	-0.28***	(-4.26)	-0.16***	(-2.32)
Difference (SOEs and non-SOEs)		-0.33***	(-3.16)	-0.37***	(-3.44)

This table provides the results for the state ownership and market reaction to the carbon neutrality commitment in different industries. This study calculates CARs using the market model and market-adjusted model. CARs are multiple by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. The event window is the (0, 1). The estimation window starts from 210 trading days to 10 trading days before the announcement date. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.4.6. The effect of carbon neutrality commitment on SOEs' firm value and carbon emission performance

In this section, this research investigates the effect of this commitment on firms, such as whether the commitment harms the value of SOEs more than that of non-SOEs due to their efforts to meet the commitment's targets. This study uses the DID approach to estimate the effect of carbon neutrality commitment on firm value and carbon emissions intensity. The treatment group consists of the listed SOEs, while the control group is the listed non-SOEs. The specification is as follows:

$$TOBINQ/Carbon\ Intensity = \beta_0 + \beta_1 SOE * POST + \beta_i FirmControls + Firm\ FE + Year\ FE + \epsilon_{i,t} \tag{4.9}$$

Where *TOBINQ* is the firm market capitalization plus book value of liabilities as a ratio of total assets. Carbon intensity as a firm's total carbon emission (scope1, scope2 and scope3) divided by its market capitalization. *SOE* is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. *POST* is a dummy variable equal to one if the year is after the carbon neutrality commitment, and zero otherwise. Firm-level control variables include the *LEV, ROA, LNMV, SALEGROWTH, BM* and *AGE*. The firm and year fixed effect are included in this model.

Column (1) of Table 4.16 reports the DID estimation result for carbon neutrality commitment and firm value from 2018 to 2022. The coefficient of *SOE*POST* is -0.07 and significant at 1% level. This result indicates that the carbon neutrality commitment exerts a negative influence on SOEs' market value. Environmental commitments of SOEs align with state expectations and needs. SOEs needed to allocate substantial funds towards technological advancements, optimize the energy structure, and reduce reliance on high-pollution, high-carbon energy sources. Therefore, SOEs may experience a decline in their financial performance, which has a negative effect on their market value. This result further reinforces the research hypothesis 1.

This study uses the DID approach based on Eq. (4.9) to further test the effect of carbon neutrality commitment on carbon emission performance. Column (2) of Table 4.16 shows that the interaction term between *SOE* and *POST* is negative and significant at 5% level. This result suggests that the carbon neutrality commitment has significantly suppressed the carbon emissions of SOEs. It is evident that SOEs have taken effective measures to improve their carbon efficiency and reduce their carbon emissions after committing to carbon neutrality. This finding confirms that SOEs indeed have actively taken responsibility for carbon neutrality rather than engaging in superficial green behaviours.

Table 4.16 The long-term effect of carbon neutrality commitment on SOEs' firm value and carbon emission performance

	(1) TOBINQ	(2) Carbon Intensity
*SOE*POST*	-0.07***	-0.19**
	(-2.75)	(-2.22)
Leverage	0.12	0.23*
	(0.75)	(1.89)
ROA	-0.01	-0.25
	(-0.07)	(-0.92)
LNMV	0.12***	0.08
	(3.29)	(1.04)
SALEGROWTH	-0.01	0.04*
	(-1.55)	(1.88)
AGE	-0.30***	0.15
	(-5.76)	(1.28)
BM		0.34*
		(1.84)
Constant	0.76	-1.61
	(1.27)	(-1.03)
Firm Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Observations	13436	7919
R-squared	0.8015	0.4545

This table provides the results from the effect of carbon neutrality commitment on SOEs' firm value and carbon emission performance. TOBINQ is the firm market capitalization plus book value of liabilities as a ratio of total assets. Carbon intensity as a firm's total scope1, scope2 and scope3 emission divided by its market capitalization. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. POST is a dummy variable equal to one if the year is after the carbon neutrality commitment, and zero otherwise. Firm-level control variables include the LEV, ROA, LNMV, SALEGROWTH, CAPEX and AGE. The firm and year fixed effect are included in this sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.5. Conclusions

Since the Paris Agreement, countries have made commitments to reduce their carbon emissions giving rise to global warming. In September 2020, China pledged to reach carbon neutrality by the mid-21st century. On one hand, SOEs are dedicated to promoting economic growth and enhancing public benefits, an important part of the economic system. On the other hand, SOEs are responsible for producing a majority of carbon emissions. To achieve the national goal of carbon neutrality, SOEs must contribute to carbon emissions reduction efforts. This study has explored the role of state ownership vs. non state ownership in achieving carbon neutrality, in terms of differential market reactions to the carbon neutrality commitment announcement.

The major results are as follows. First, the market expects SOEs to complete national carbon neutrality tasks to a greater extent than non-SOEs, which is reflected by the finding that SOEs face more negative market reactions to carbon neutrality commitment. Second, CSOEs are more likely than LSOEs to comply with government policies, which elicits a more significant negative market reaction. Third, the market perceives that SOEs with higher CSR performance take more actions to achieve carbon neutrality commitments than do SOEs with low CSR performance; hence, firms in the former category face more negative market reactions. Further analysis shows that the social responsibility placed on SOEs is the driving force behind their efforts to achieve carbon neutrality rather than the low carbon efficiency of SOEs. Furthermore, the market also expects SOEs that are cross-listed and non-cross-listed, in carbon-intensive and non-carbon-intensive industries, as well as those in both eastern and non-eastern regions, to actively reduce their carbon footprints and assume greater environmental responsibilities. Negative market reactions are less strong in the QFIIs-owned firms than SOEs as QFIIs-owned firms could have favourable environmental performance and lower greenhouse gas emissions than SOEs. This further contributes to the negative market reactions observed for SOEs. Moreover, the DID estimation results indicate that SOEs suffer a decline in firm value (measured by Tobin Q) and reduce carbon emissions following the government's commitment to carbon neutrality. The findings confirm that SOEs indeed take more responsibility in reducing carbon emissions, thereby experiencing a decline in firm value.

The contributions of this study are manifold. First, this study contributes new empirical evidence to the debate on state ownership and environmental performance. The findings indicate that SOEs take more responsibility than non-SOEs in response to China’s carbon neutrality policy. Second, this study contributes to the growing research on carbon neutrality in China. To the best of knowledge, this is the first study to examine the impact of state ownership on efforts to achieve a carbon neutrality commitment. The empirical findings show that compared with non-SOEs, SOEs are required to take greater responsibility for meeting national carbon dioxide reduction targets and achieving sustainable social transformation due to their state-owned nature. Third, the findings can contribute to both policy implications and market practices. Carbon neutrality will not be achieved overnight. The findings indicate that the government should strengthen its supervision of SOEs to promote their optimisation of energy structures and promote synergies to reduce pollution and carbon emissions. The government also should provide policy support to SOEs to promote the transformation and upgrading of industrial structures and strengthen the innovation and application of green and low-carbon technologies, which may help to improve SOEs' carbon efficiency and reduce the negative financial impact of reducing carbon emissions. The findings also inform recommendations for market investment. Investors should consider the type of corporate ownership and assess the effects of environmental policies on stock performance.

Chapter 5. Third-party Certification on Green Bond Issuances and Corporate Green Transformation

5.1. Introduction

This chapter focus on the impact of market-driven incentives on corporate green transformation. A fundamental transformation of the economic system to achieve climate goals requires companies to invest in green activities that reduce their carbon emissions, boost their energy efficiency and enable them to adopt green technologies and sustainable supply chain practices. Such activities necessitate substantial financial support (Hong et al., 2020). Green bonds are considered a suitable instrument for financing the transition to a low-carbon economy (Pástor et al., 2022) because they direct capital flows away from traditional activities towards green projects and support green projects by lowering the cost of debt (Zerbib, 2019; Tang and Zhang, 2020). However, some companies may use the proceeds from green bond issues to fund their daily operating costs or even to fund brown projects instead of investing in environmentally friendly projects (Jankovic et al., 2022). To bolster the credibility of green bonds, the role of independent third-party certification is becoming increasingly vital (Fatica et al., 2021). However, empirical evidence on whether and how firms can benefit from third-party certification remains scant. This study aims to fill this gap in the literature by empirically examining the role of third-party certification of green bond issuances in corporate green transformation based on a sample of green bond issuances in China.

The Chinese green bond market provides a unique opportunity to study the value of third-party certification in green bond issuance. China is the largest carbon dioxide emitter in the world. To achieve sustainable development, it began promoting green bond development in 2016 and has subsequently developed the world's second largest green bond market. However, the growth of the green bonds market in China has raised some concerns. One pressing concern is the discrepancy between the definition of green projects outlined in China's green bond guidelines[6] and the international standards for

[6] Guidelines for the Issuance of Green Bonds:
https://www.ndrc.gov.cn/xxgk/zcfb/tz/201601/t20160108_963561.html

green investment. China permits funds raised from green bonds to be utilised as general working capital, leading to nearly 50% of Chinese green bonds failing to meet the criteria established by the Climate Bond Initiative (CBI) for such bonds funding investment in green projects. Therefore, international investors have expressed doubts about the actual ‘green’ attributes of China’s green bonds. In addition, insufficient information disclosure in the green bond market has further weakened investor confidence. Moreover, some issuers have not effectively managed their environmental risks after green bond issuance, and environmental violations by green issuers can even increase after issuance (CBI, 2022).[7] The introduction of independent third-party agencies to evaluate and certify green bonds is emerging as a potential solution to these credibility issues and could help investors to differentiate green bond issuers that will genuinely improve their environmental performance from issuers that only use green bonds as a greenwashing tool. However, less than 50% of green bonds in China have been certified by a third-party agency. It remains unclear whether and how third-party certification can engage green bond issuers to exert genuine decarbonisation efforts.

To answer the question of whether third-party certification generates real economic and environmental impacts on green bond issuers, this study firstly investigates Chinese listed firms that issued green bonds over the period 2016–2022 and compare short-term stock market reactions to green bond issuance announcements for issuers with and without third-party certification, as well as their long-term stock performance. The results from this event study indicate that the capital market does not respond significantly to overall green bond issuance, but there are positive and significant market reactions when certified green bonds are issued, and there are negative market reactions to announcements of non-certified green bonds. Specifically, this study observes cumulative abnormal returns of 1.32% and 1.61% using a market-adjusted model and a three-factor model, respectively, during a 16-day event window around green bond issuance announcements. By comparison, the cumulative abnormal returns are -1.91% and -0.83% for non-certified bonds for the same two models during the same event window. The differences in market reactions between certified green bonds and non-certified green bonds are highly significant. This study also demonstrates that

[7] CBI (2022). Green Bond China Investor Survey.
https://www.climatebonds.net/files/reports/cbi_china_investor_survey_0.pdf

BHAR are positive and significant (non-significant) for certified (non-certified) green bonds 11 months after issuance. The results remain robust to the selection of alternative models for the event study and the use of different event windows. In summary, the findings show that the capital market only reacts positively to the issuance of certified green bonds, suggesting that third-party certification is valuable in green bond issuance. These results align with studies highlighting the positive impact of certification on firm value in the short and long run (Sufi, 2009; Eichholtz et al., 2019).

This study then examined three channels that the third-party certification in green bond issuance can benefit issuers, including whether it encourages issuers to generate positive environmental impacts. The information asymmetry channel argues that third-party certification leads to increased disclosure of relevant environmental and financial information, reducing information asymmetry between investors and firms. The greenwashing prevention channel argues that certification deters companies from only making false environmental claims in sourcing green finance, reduces investors' screening cost for green projects, and hence attracts impact investors, thereby elevating stock prices and enhancing firm value. Lastly, the environmental performance channel posits that green bond certification can generate real effect on corporate environmental efforts and improve a company's environmental rating, thus positively influencing its value.

The empirical findings offer robust evidence supporting these channels. Specifically, this study observes a significant decrease in stock price synchronicity following the issuance of certified green bonds, indicating that certification enables companies to provide more information to the market, thus diversifying stock information and reducing information asymmetry. In addition, this study finds a significant negative impact on greenwashing, as measured by the differences between the ESG disclosure rating and the ESG rating after the issuance of certified green bonds, indicating the effectiveness of certification in deterring potential corporate greenwashing. Furthermore, companies issuing certified green bonds experience a significant improvement in their ESG ratings compared with non-certified issuers, confirming the positive influence of certification on environmental performance. In summary, this study documents that the third-party certification of green bonds can generate positive economic and environmental effects for issuers, which can benefit investors. The results remain robust when this study conducts a series of robustness tests, including placebo, instrumental variable and entropy balancing tests, to address potential endogeneity issues, and when this study reconstructs the sample to address concerns regarding potential collusion between certified green bond issuers and third-party certification institutions.

The further analysis confirms that third-party certification helps green bond issuers attract long-term investors, increases analyst coverage and induces positive opinions about disclosure quality from regulators. This study finds a 1.48% increase in the long-term institutional ownership of green bond issuers after they issue certified green bonds, which is probably driven by the interest of investors in real environmental and economic improvements subsequent to green bond issuance. The results show that after third-party certification, the analyst coverage of certified green bond issuers increases by 32% more than that of green bond issuers without third-party certification and that information disclosure ratings published by the CSRC improve after third-party certification. These findings can explain the increase of long-term market valuation among green bond issuers after third-party certification. This study also document that the third-party certification reduces the carbon intensity of certified green bond issuers by 4%. In sum, this study reveals that market-based instrument can facilitate corporate green transformation and meanwhile generate positive values.

The remainder of this chapter is structured as follows. Section 5.2 provides an overview of the institutional background and review relevant research to lay the foundation for the development of the research hypotheses. Section 5.3 outlines the process of constructing the sample of green bonds and describes the sources of data used in our analysis. In section 5.4 presents the empirical results of this study. Finally, in section 5.5 draw conclusions based on the findings.

5.2. Institutional background, literature review and hypothesis development

5.2.1. Institutional background

According to established China's green bond guidelines, green bonds are securities that raise funds specifically to support eligible green industries, projects or economic activities. In January 2016, Shanghai Pudong Development Bank issued the first green bond in China's domestic bond market. To promote the development of the Chinese green bond market, the People's Bank of China (PBC) and the National Development and Reform Commission released several important documents in December of that year. These include the 'Announcement on Matters Related to the Issuance of Green Financial Bonds', the 'Catalogue of Green Bond Support Projects' and the 'Guidelines for the Issuance of Green Bonds'.[8] These documents provide guidance and regulations on various aspects of green bonds, such as defining green projects, specifying the direction of raised funds, managing funds during the bond's tenure, disclosing information and requiring evaluation or certification by independent institutions for green financial bonds.

The release of these documents marked the official launch of the Chinese green bond market, which has since experienced robust growth. Currently, China ranks as the world's second largest market for green bond issuance, with the cumulative domestic and international issuance of green bonds reaching a staggering USD 489 billion at the end of 2022.[9] As China plans to increase investment in green industries in the long term, substantial capital support will be required for the green transformation of the economy. From 2021 to 2050, China's total investment demand for green and low-carbon fields is projected to reach 487 trillion yuan, with approximately 90% of the funds being raised through the financial market.[10] The green bond market offers new and efficient financing channels for financial institutions and green enterprises. As a long-term and stable source of financing, green bonds effectively mitigate the risk of maturity mismatch for green industry projects.

[8] Announcement on Matters Related to the Issuance of Green Financial Bonds:
https://www.gov.cn/xinwen/2015-12/22/content_5026636.htm
Catalogue of Green Bond Support Projects:
http://www.pbc.gov.cn/tiaofasi/144941/3581332/3588085/2018080814554619837.pdf
Guidelines for the Issuance of Green Bonds:
https://www.ndrc.gov.cn/xxgk/zcfb/tz/201601/t20160108_963561.html

[9] China Sustainable Debt State of the Market Report 2022:
https://www.climatebonds.net/resources/reports/china-sustainable-debt-state-market-report-2022

[10] China's green finance expands this year thanks to policy support:
https://en.imsilkroad.com/p/326517.html

However, the rapid growth of the green bond market has raised concerns regarding the 'fairness' of these bonds. Recent research reveals that green bond funds are often used to repay corporate debts or to bolster daily liquidity rather than being fully invested in environmentally friendly projects (CBI, 2020).[11] In 2020, only 28% of the funds raised from green bonds were explicitly disclosed as being used for new green projects; 10% were allocated to debt refinancing or to existing projects; and 51% of green bond issuers did not disclose how the proceeds would be used.[12] In addition, before 2021, brown companies with high carbon emissions, such as coal-powered power plants, were allowed to issue green bonds.[13] A further concern is the lack of transparency by issuers of green bonds when revealing information on matters such as capital flows, project progress and the environmental performance of projects (Ehlers and Packer, 2017). The information asymmetry between issuers and investors poses challenges for accurately assessing the environmental attributes of projects and undermines investor confidence in green bonds. To address these issues and enhance the credibility of green bonds, independent certification and evaluation have become indispensable in providing objective assessments and instilling investor trust (Baker et al., 2022).

Companies are encouraged by the Chinese government to engage third-party certification institutions when issuing green bonds. These agencies conduct independent audits to determine whether the green bonds adhere to specific green bond frameworks or standards. There are four main types of third-party certification institutions for Chinese green bonds: accounting firms, professional consulting companies, credit rating agencies and academic institutions. Most of these agencies are recognised by the Green Bond Standards Committee or the CBI as qualified green bond certification service providers. Green bonds certified by a third party provide greater details of the implementation of green projects before and after the issuances (see the

[11] CBI. (2020). China Green Bond Market Report 2020.
https://www.climatebonds.net/files/reports/cbi_china_sotm_2021_06c_final_0.pdf

[12] CPI (2020). The State and Effectiveness of the Green Bond Market in China:
https://www.climatepolicyinitiative.org/wp-content/uploads/2020/06/The_State_and_Effectinevess_of_the_Green_Bond_Market_in_China.pdf

[13] China Green Bond Market Report 2021:
https://www.climatebonds.net/files/reports/cbi_china_sotm_2021_0.pdf

comparisons of the disclosure documents for a certified green bond and a non-certified green bond in Appendix C1) than is the case for uncertified green bonds. Specifically, before the issuance of green bonds, third-party certification agencies conduct a comprehensive evaluation of the management and administrative processes involved in the issuance. This evaluation includes a review of project compliance, strategies for fund utilisation and management and information disclosure policies, as well as an assessment of the project's environmental performance. Throughout the issuance period, the certification agency continues to engage with the issue by conducting and releasing tracking assessments and certification reports, analysing fund utilisation compliance, verifying adherence to project criteria, evaluating environmental benefits and assessing the issuer's information disclosure practices. Thus, voluntary compliance with regulations for green bond issuance, scrutinised and certified by third-party institutions, could enhance market transparency, boost investor confidence and deter unauthorised changes in fund usage or false claims of green attributes by companies.

5.2.2. Literature review and hypothesis development

Studies on green bonds focus on whether such bonds have a green premium over traditional bonds. The evidence on this issue remains debatable. Some studies suggest that investors prefer to pay a green premium relative to non-green bonds to purchase green bonds (Zerbib, 2019; Fatica et al., 2021; Baker et al., 2022). Zerbib (2019) finds that the yields of green bonds are much lower than the yields of conventional bonds with similar features. Fatica et al. (2021) reveal that green issuers with credibility and reputations issue green bonds at lower yield spreads than other issuers. Baker et al. (2022) document a green premium in US municipal green bonds. However, some studies show that green bonds do not have a substantial yield premium or discount compared with conventional bonds (Larcker andd Watts, 2020; Flammer, 2021). For instance, comparing green bonds and similar non-green bonds issued by the same companies, Larcker and Watts (2020) find no evidence of a green premium and suggest that investors are not willing to pay more for investment in green versus non-green projects. Some studies argue that green bonds can be cheaper than non-green bonds only when they are certified. Li et al. (2022) find that green features alone do not reduce the financing cost for issuers and that only officially certified green bonds can effectively reduce yield spreads. Fatica et al. (2021) document that green bonds certified by external auditors are eligible for a discount of about 6 basis points.

Several studies investigate whether and how issuers can benefit from green bond issuance and demonstrate that the announcement of green bond issuance is associated with positive market reactions (Tang and Zhang, 2020; Flammer, 2021; Pástor et al., 2022). Studies document the possible mechanisms, which include the following arguments: 1) the issuance of green bonds can improve stock liquidity (Tang and Zhang, 2020); 2) corporate engagement in sustainable financing practices can improve the firm's financial performance in the long run and thus are favoured by shareholders (Khan et al., 2016; Tang and Zhang, 2020); and 3) the issuance of green bonds serves as a reliable signal of a firm's commitment to the environment (Flammer, 2021). These studies focus on the benefits of green bond issuance to issuers; however, none of them explore the real impacts of third-party certification on the firms that issue green bonds.[14]

The presence of third-party certification provides external stakeholders with specific information about the issuers' green projects. Third-party certification institutions review the issuers' adherence to green practices, disclose the environmental and financial benefits of green projects and monitor the use of proceeds from green bonds. Consequently, this certification plays a crucial role in providing extra information about issuers to the capital market, reducing the screening and monitoring costs of external investors in evaluating the authenticity of a project's environmental benefits, and alleviating investors' concerns about greenwashing. It also attracts impact investors who are willing to devote capital to green projects. Ultimately, these factors lead to an increase in the market valuation of the company. Therefore, the first hypothesis is as follows:

Hypothesis 1: Third-party certification increases the market valuation of green bond issuers.

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[14] Studies of third-party certification demonstrate that environmental labelling using the International Organization for Standardization (ISO) or Environmental Labeling Certification (ELC) systems augment product sales, facilitate market entry, confer cost and differentiation advantages to firms and contribute to overall profitability (Goedhuys and Sleuwaegen, 2016; Testa et al., 2018; Zhou et al., 2023). This study focuses on labelling in green bond issuance.

This study proposes three potential mechanisms through which third-party certification can improve the market valuation of green bond issuers. Effective decision-making processes in economic, environmental and management decisions rely heavily on reliable and accurate information (Amiram et al., 2016). Investors require such information to make informed decisions regarding environmental issues. However, companies often possess more comprehensive information about their own characteristics and behaviours than investors, resulting in information asymmetry, which increases the costs of market transactions (Derrien et al., 2016). Often, environmental certification serves as an effective means to resolve information asymmetry in this context (Holtermans and Kok, 2019). Research indicates that the disclosure of environmental information facilitated by environmental certification provides valuable company-specific information, enabling investors to analyse the impact on company value and thus ultimately reducing information asymmetry (Ehlers and Packer, 2017).

According to the 'Green Bond Assessment and Certification Behaviour Guidelines[15]' proposed by the PBC and the CSRC, when issuing certified green bonds, the third-party certification institution is tasked with assessing the issuer's internal governance and the compliance of green projects and disclosing the projects' financial and environmental performance. The supervision by these third-party certification institutions ensures that companies disseminate complete and accurate information to the market, which is conducive to inhibiting companies' incentives to hide negative information (An et al., 2020). In addition, third-party certification stimulates extra disclosure and greater attention from investors, analysts and the media than non-certified green bonds. Hence, third-party certification can boost the market valuation of green bond issuers through an increase in non-financial exposure (Fatica et al., 2021), which reduces the information asymmetry of green bond issuers in the market. This leads to the next hypothesis:

Hypothesis 2a: Third-party certification reduces the information asymmetry of green bond issuers.

[15] Green Bond Assessment and Certification Behaviour Guidelines:
https://www.gov.cn/gongbao/content/2018/content_5271800.htm

Green bonds have been subject to scrutiny because they can be used as a potential form of greenwashing, whereby companies may use them to appear environmentally responsible without taking genuine action to protect the environment (Flammer, 2021). Some studies find evidence of greenwashing in the context of green bonds. For example, Shi et al. (2023) highlight that companies take advantage of the low cost of capital from issuing green bonds without taking tangible actions to increase green investments. Tuhkanen and Vulturius (2020) note a disconnect between issuers' climate goals and their green bond framework, as well as several deficiencies in issuers' post-issuance reporting. Greenwashing can negatively affect a firm's financial performance (Walker and Wan, 2012; Kim and Lyon, 2015). Nyilasy et al. (2014) reveal that consumers are unlikely to purchase products from a company that promotes green advertising but has a low environmental performance score than from other counterpart companies. This incongruity negatively affects the company's revenue. Du (2015) finds that when a company is exposed to greenwashing behaviour, investors will become convinced that the company is not environmentally friendly and that its green claims are dishonest. As a result, investors develop a negative perception of the company, leading to a decreased valuation.

Third-party certification helps investors screen green investments and reduce their information collection costs before the issuance of green bonds. In the post-issuance period, third-party certification enables investors to monitor the allocation of green funds and ensure that they are utilised for genuine green projects rather than being diverted to brown industries. It also verifies the environmental benefits associated with green projects and prevents green bond issuers from adopting greenwashing strategies. Third-party certification can boost the market valuation of green bond issuers by reducing investors' screening and monitoring costs and mitigating the negative effects of greenwashing. Therefore, this study proposes the following:

Hypothesis 2b: Third-party certification reduces greenwashing by green bond issuers.

The last mechanism that this study explores is the role of third-party certification in inducing green bond issuers to exert real environmental efforts, leading to improved environmental performance. Companies that issue green bonds are supposed to reduce their carbon emissions by investing the funds that they raise through green bonds in green projects (Flammer, 2021). Third-party certification is essential to prevent companies from engaging in greenwashing and to ensure that they actually improve their environmental performance. Green bond issuances with third-party certification are expected to improve overall ESG performance. Studies find that high ESG performance reduces firm risk and improves financial performance (Flammer, 2015; Gao and Zhang 2015; Ferrell et al. 2016; Gillan et al., 2021), leading to more favourable bond ratings and lowering the bond yield spread (Stellner et al., 2015; Hossain et al., 2023) and the cost of equity (Hong and Kacperczyk, 2009; El Ghoul et al., 2011). Hence, third-party certification could improve the market valuation of green bond issuers by inducing improvements in ESG performance. Thus, this study proposes the following:

Hypothesis 2c: Third-party certification improves the ESG performance of green bond issuers.

5.3. Data, variables and methodologies

5.3.1. Data, sample and variables

This research collected green bond data from the Choice financial terminal (Choice) to compile a sample of listed green issuers. This study retrieved all bonds in the Choice database that were labelled as 'green bonds' and then excluded the following: 1) green bonds issued by non-listed firms, because the research focuses on the green bond certification value of listed firms; 2) green bonds issued by overseas listed firms; 3) asset-backed green bonds and private placement green bonds;[16] and 4) 31 green bonds issued by listed firms before they were listed. As a result of these filtering measures, the final sample consists of 203 green bonds issued between 1 January 2016 and 31 December 2022. This study constructs two samples: a sample of green bond issues, which enables us to investigate market valuations of third-party certification, and a firm sample of green bond issuers to explore the real effects of third-party certification.

[16] These bonds were excluded from our sample following Tang and Zhang (2020). Asset-backed green bonds have a distinct structure compared with regular green bonds. They may not yield real effects on companies that initiate the bond issuances because the proceeds are used for a special purpose entity. Private placement green bond issuers do not publicly release information.

Table 5.1 shows the numbers of green bonds, certified green bonds and non-certified green bonds in China from 2016 to 2022. In 2016, the total issuance amount was CNY 1,138 billion, with 13 green bonds. By 2022, this figure had reached CNY 2,608 billion, with 94 green bonds. Columns (4) and (5) of Table 1 show the numbers of certified and non-certified green bonds, respectively, issued from 2016 to 2022. In 2020, the number of certified green bonds surpassed that of non-certified green bonds. The number of listed green bond issuers has been increasing year by year.

Table 5.1 The number and size of green bond issuance

Year	N of Green Bonds	Amount (Billion, CNY)	N of Certificated Green Bonds	N of non-certificated Green Bonds	N of Listed Green Bond Issuers
2016	13	1,138	0	13	8
2017	11	563	2	9	10
2018	11	692	1	10	9
2019	16	443	3	13	13
2020	13	188	7	6	11
2021	45	572	28	17	32
2022	94	2,608	67	27	57
Total	203	6, 204	108	95	140

This table shows the number and amount of green bond issues in China from 2016 to 2022. The number of certificated green bonds, non-certificated green bonds, as well as the number of listed green bond issuers are also included in this table.

This study obtained the ESG performance data from Huazheng to test the environmental performance channel. Huazheng specialises in providing objective, standard and time sensitive ESG data to investors to assist them in assessing the sustainability of companies and investment portfolios (Zhang, 2023). This study collected firms' ESG disclosure scores from the Bloomberg database. The Bloomberg ESG disclosure score is widely used to quantify the level of ESG information disclosed by companies, with higher scores indicating greater ESG-related disclosures (Christensen et al., 2022).

This study collected stock market data and financial statement data, including stock returns, market returns, stock trading volumes, accounting data, institutional ownership data, analysts' coverage and CSRC information disclosure rating data, from the CSMAR database. CSMAR includes various subcategories of institutional investors, such as foreign qualified investors, pension funds, trusts, banks and insurance companies. This study follows Kim et al. (2019) in defining long-term institutional investors as pension funds, trusts, banks and insurance companies. Long-term institutional ownership (*LTIO*) is measured by the number of shares held by long-term institutional investors to the total number of shares. Analysts' coverage (*ANACOV*) is measured by the log of the number of analysts following the company. The information disclosure rating (*IR*) is a rating published by the CSRC on the quality of information disclosure by listed firms. It rates companies on four levels, ranging from D (worst) to A (best). This study converted the rating into a score based on a scale from 1 to 4.

The market valuation of green bond issuance is determined by both the short-term market reaction to the announcement of green bond issuance, and the long-term stock performance subsequent to the issuance. The short-term market reaction can be measured through an event study approach based on the market-adjusted model and the Fama–French three-factor model (FF3). Following Flammer (2021) and Tang and Zhang (2020), this study selects an event window spanning 5 days before to 10 days after the announcement date. The estimation window starts from 280 trading days to 30 trading days before the announcement date. The cumulative abnormal return (CAR) from the market-adjusted model (*CAR1*) is calculated by the sum of the daily market-adjusted return (the actual return minus the market return) in the event window. The CAR from the FF3 (*CAR2*) is the sum of daily abnormal returns in the event window, where the daily abnormal return is the actual return minus the predicted return from the three-factor model (Liu et al., 2019). The long-term market valuation is measured by the BHAR, following Barber and Lyon (1997). The BHAR is calculated by the difference of the cumulative raw returns of a green issuer 11 months subsequent to a green bond issuance minus the cumulative expected return in the period.

Following Chan and Hameed (2006) and Gul et al. (2010), this study applies stock price synchronicity (*SYNCH*) to assess information asymmetry. This study calculates SYNCH from the R-squared in the following market model:

$$RET_{i,t} = \beta_0 + \beta_1 MKTRET_t + \beta_2 MKTRET_{t-1} + \beta_3 INDRET_t + \beta_4 INDRET_{t-1} + \epsilon_{i,t} \qquad (5.1)$$

where $RET_{i,t}$ is the daily stock return for firm i, $MKTRET$ and $INDRET$ denote the value-weighted market return and industry return, respectively. The market return is calculated based on the weighted average return of all stocks traded on the Shanghai and Shenzhen exchanges. The industry return is determined using all firms belonging to the same industry as firm *i*. To mitigate concerns about potential asynchronous trading bias in estimating market models using daily returns, this study includes the lagged industry return ($INDRET_{t-1}$) and market return ($MKTRET_{t-1}$) in Eq. (5.1), following the approach of Gul et al. (2010). $\epsilon_{i,t}$ is the unspecified random factors. To ensure the accuracy of the analysis, we follow Gul et al. (2010) in excluding firms with less than 200 trading days of shares traded in each fiscal year.

Considering that R-squared is skewness and bounded between [0, 1], this study employs a logistic transformation to exhibit a near-normal distribution variable, *SYNCH*. A higher *SYNCH* value suggests more synchronised stock prices, which indicates greater firm information asymmetry (Chan and Hameed, 2006). Thus, this study has

$$SYNCH_i = \log\left(\frac{R_i^2}{1-R_i^2}\right) \qquad (5.2)$$

here $SYNCH_i$ is the empirical measure of quarterly synchronisation for firm *i*.

The greenwashing index (*GW*) is calculated by the difference between a firm's ESG disclosure rating and its ESG rating, following Zhang (2023).

$$GW_{i,t} = \left[ESG_{\text{Disclosure i,t}} - \overline{ESG_{\text{Disclosure}}}\right)/\sigma ESG_{\text{Disclosure}}\Big] - \left[ESG_{\text{Rating i,t}} - \overline{ESG_{\text{Rating}}}\right)/\sigma ESG_{\text{Rating}}\Big] \qquad (5.3)$$

where $ESG_{\text{Disclosure i,t}}$ represents firm *i*'s Bloomberg ESG disclosure score at time *t*. The $\overline{ESG_{\text{Disclosure}}}$ is measured by all firms from the same industry, with firm *i*'s Bloomberg ESG disclosure score omitted. $\sigma ESG_{\text{Disclosure}}$ is the standard deviation for the industry ESG disclosure score. $ESG_{\text{Rating i,t}}$ is firm *i*'s Huazheng ESG rating at time *t*. $\overline{ESG_{\text{rating}}}$ is measured by all firms from the same industry, with firm i's Huazheng ESG rating omitted. $\sigma ESG_{\text{Rating}}$ is the standard deviation for the industry ESG rating. $GW_{i,t}$ is the greenwashing indicator for firm *i* at time *t*.

Corporate ESG performance is measured by the ESG ratings published by Huazheng. Huazheng ESG ratings use a rating scale consisting of nine levels, ranging from C to AAA. To facilitate analysis and comparison, this study converts these letter-based ratings into numerical scores. AAA is assigned the highest score of 9 points, followed by AA with 8 points, A with 7 points, BBB with 6 points, BB with 5 points, B with 4 points, CCC with 3 points, CC with 2 points and C with 1 point. This conversion allows for a standardised and quantifiable assessment of the ESG performance of companies rated by Huazheng.

Following Ferrell et al. (2016), Tang and Zhang (2020) and Peng et al. (2023), this study selects leverage, return on assets (ROA), firm size, cash, sales growth and state ownership as the firm-level control variables. Leverage (LEV) is calculated by the ratio of total debt to total assets, and ROA is calculated by dividing net income by total assets. Firm size (SIZE) is represented by the logarithm of market value and cash (CASH) is defined as the ratio of cash to total assets. Sales growth (Growth) is defined as the ratio of the change in sales to lagged sales. State ownership (SOE) refers to a green bond issuer owned by a state or a state-controlled institution. Research suggests that peer effects significantly influence corporate behaviour, including financial decisions and social responsibility initiatives (Leary & Roberts, 2014; Cao et al., 2019). Therefore, we incorporate the peer certification ratio (PCR) as a control variable. PCR is calculated based on the green bond certification ratio of rival firms within the same region and industry. This study follows Chan and Hameed (2006) in controlling the trading volume (*VOLUME*) and stock return volatility (*VOL*) to test the information asymmetry channel. The former refers to the total number of shares of a company that are traded in a given quarter divided by the number of shares outstanding and the latter to the standard deviation of stock returns. To mitigate the effect of outliers, all firm control variables are winsorised at the 1st and 99th percentiles of their empirical distributions.

Table 5.2 shows the summary statistics at the firm level. The short-term market reaction ranges from -16.746% to 26.382%, and the long-term BHAR ranges from -46.512% to 95.744%. The mean values of trading volume and stock return volatility are 6.177 and 0.023, respectively. For the financial statement, the average leverage ratio is 61.9%. The range for the ROA is -0.155 to 0.163. Firm size ranges from 14.231 to 20.976, and the mean of cash flow is 8.7%. The average sales growth and industry certification ratio are 34.40% and 1.80%, respectively. A total of 74% of green bond issuers are owned by the state or a state-controlled institution. During the sample period, the maximum of stock price synchronicity is 4.033 and the minimum is -4.326. The average of greenwashing index is -0.087 and the range is between -2.364 to 2.776. The mean value of the ESG rating is 4.866. The average ratio of the number of shares held by long-term institutional investors to the total number of shares.is 8.767%. The average analyst coverage and information disclosure ratings are 2.226 and 2.597, respectively.

Table 5.2 Summary statistics

	N	Mean	Std. Dev.	Min	Max
Bond-level variables:					
Label	203	0.532	0.500	0	1
CAR1	203	0.465	7.522	-16.746	26.382
CAR2	203	-0.126	7.263	-16.465	23.370
BHAR	203	7.048	26.036	-46.512	95.744
Firm-level variables:					
Post	2,972	0.275	0.447	0	1
Certified	2,972	0.649	0.477	0	1
VOLUME	2,940	6.177	1.094	3.012	8.650
VOL	2,938	0.023	0.012	0.006	0.062
LEV	2,972	0.619	0.157	0.163	0.951
ROA	2,937	0.022	0.025	-0.155	0.163
SIZE	2,936	17.253	1.283	14.231	20.976
CASH	2,972	0.087	0.066	0	0.518
GROWTH	2,921	0.344	0.784	-0.911	2.961
SOE	2,972	0.741	0.438	0	1
PCR	2,972	0.018	0.066	0	1.167
LNTPC	2,972	1.790	0.724	0	2.485
SYNCH	2,970	0.086	1.050	-4.326	4.033
GW	2,476	-0.087	1.035	-2.364	2.776
ESG	2,972	4.866	1.151	1	7
LTIO	929	8.767	8.887	0.029	62.988
ANACOV	929	2.226	1.150	0	4.205
IR	929	2.597	1.610	0	4

This table reports the summary statistics. Bond-level variables include the label, cumulative abnormal return (CAR1 and CAR2), and buy and hold abnormal return (BHAR). The CARs and BHAR are multiplied by 100. Firm-level variables include the stock price synchronicity (SYNCH), the greenwashing index (GW) and ESG performance (ESG). It also provides the variables for the further analysis, such as the share of long-term institutional investors (LTIO), analyst converge (ANACOV) and information disclosure rating (IR). The definition for these variables is displayed in Appendix C2.

5.3.2. Methodology

This study applies a standard event study approach to explore the market reactions to green bond issuances and compare the different market reactions of certified and non-certified green bonds. The following regression model that compares CARs/BHAR for certified green bonds and non-certified green bonds is adopted to test H1:

$$CAR/BHAR = \beta_0 + \beta_1 Label + \beta_i FirmControls + Industry\ FE + \epsilon_{i,t} \quad (5.4)$$

Here, *CAR* refers to the cumulative abnormal return calculated from the market-adjusted model (*CAR1*) or the FF3 (*CAR2*). *BHAR* is the difference between the return on a buy-and-hold investment and the corresponding expected return. $Label$ is the key independent variable, which equals one if a green bond is certified by a third-party agency, and zero otherwise. Firm controls are a set of firm-level financial characteristics variables, including ROA, firm size, cash, leverage, sales growth, state ownership, and peer certification ratio. These control variables are in the lagged year. Industry fixed effects are included in the models.

This study uses a difference-in-differences (DID) specification to test channels for the economic and environmental consequences of green bond certification in a firm-quarter sample. The specification is as follows:

$$\begin{aligned} SYNCH/GW/ESG \\ &= \beta_0 + \beta_1 Certified * Post + \beta_2 Certified + \beta_3 Post \\ &+ \beta_i FirmControls + Industry\ FE + Year\ FE + \epsilon_{i,t} \quad (5.5) \end{aligned}$$

where, as previously noted, *SYNCH* is stock price synchronicity, *GW* is the greenwashing index and ESG is the ESG rating in a firm in a quarter. The specification includes a dummy variable for green bond issuers with any certified green bonds ($Certified$) and a dummy variable for the quarters after the certification (*Post*). In the DID specification, the interaction term *Certified**Post* is the key independent variable.

Firm controls are a set of firm-level financial characteristics, including ROA, firm size, cash, leverage, sales growth, state ownership, and peer certification ratio. The stock trading volume and volatility are controlled in the test of information asymmetry. Firm-level control variables are in the lagged year. The specification incorporates industry and year fixed effects to account for potential confounding factors.

5.4. Empirical results

5.4.1. Market valuation of third-party certification in green bond issuances

This study examines the market reactions to green bond issuances in both the short and long term and compare the differences between certified and non-certified green bonds. Table 5.3 reports the market valuation of a green bond issuance announcement. Contrary to Flammer (2021) and Tang and Zhang (2020), the findings suggest that the market displays a lack of interest in green bond issuance. Specifically, Columns (3) and (5) of Table 5.3 demonstrate that there is no significant short-term market reaction for the overall sample of green bonds. However, when considering certified green bonds, this study observes a substantial and statistically significant stock market response. The discrepancies in cumulative abnormal returns (*CAR1* and *CAR2*) between certified and non-certified green bonds are statistically significant at the 1% and 5% confidence levels, respectively. In Column (7) of Table 5.3, this study observes that the BHAR of green bonds is consistently positive. Moreover, when examining the coefficient of the certified sample, this study finds that not only is it positive, but it is also significantly larger than that for the overall sample. The coefficient for non-certified green bonds is also positive, albeit non-significant. This suggests that market investors actively favour green bonds that possess third-party certification. Consequently, the findings provide support for Hypothesis 1, which posits that third-party certification serves to augment firm value.

Table 5.3 Market valuation to green bond issuance announcement

	Obs.	CAR1	t-stat	CAR2	t-stat	BHAR	t-stat
Full sample	203	-0.19	(-0.37)	0.47	(0.88)	5.59***	(3.26)
Certified green bond	108	1.32*	(1.73)	1.61*	(1.88)	8.52***	(3.29)
Noncertified green bond	95	-1.91***	(-3.16)	-0.83	(-1.52)	2.249	(0.29)
Diff. (Certified - Noncertified)		3.23***	(3.25)	2.44**	(2.33)	6.27*	(1.84)

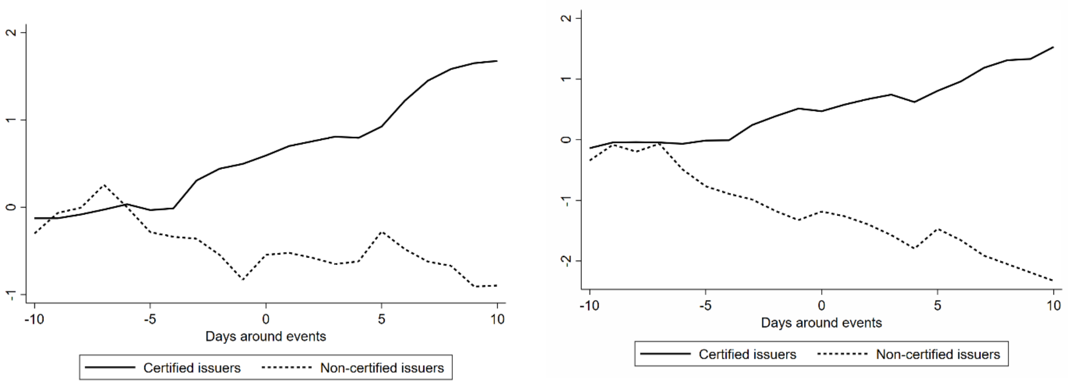
This table report the CARs and BHAR for green bond issuance. This study calculates CARs using the market-adjusted model and the Fama-French three-factor model and multiple CARs by 100. The event window spans 5 days before and 10 days after the announcement date. The estimation window starts from 280 trading days to 30 trading days before the announcement date. BHAR is the difference between the cumulative raw return on a green issuer in 11 months subsequent to green bond issuance and the corresponding cumulative expected return in the period. The BHAR is multiplied by 100. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

To ensure the robustness of the findings, this study uses the Fama–French five-factor model (Fama and French, 2015) to calculate the abnormal returns.[17] The result shows that the market only reacts positively to green bonds that are certified, with a positive and significant difference between certified and non-certified bonds, is robust. Moreover, the results remain robust when this study varies the event window to the period from 10 days before to 10 days after the announcement date. This study conducts a series of tests using BHARs for different return windows, and the results show that the returns of certified bonds are positive and significantly higher than those of the full sample. Thus, the results remain robust under different models and event window specifications.

One concern for the market valuation of third-party certification in green bond issuances is whether the positive stock market reactions are directly attributable to the announcement of third-party certification or if there were pre-existing trends that could explain the observed effects. Information leakage regarding green bond issuance prior to the official announcement is possible. Consequently, we analyse cumulative abnormal returns over an extended event window (-10 to +10 days). Figure 5.1 presents the cumulative average daily abnormal returns for certified and non-certified green

[17] The factors of the Fama–French five-factor model comprise the excess return on the market portfolio (R_M-R_F), size (SMB), value (HML), profitability (RMV) and investment (CMA) factors. This study retrieves these data from CSMAR.

bonds over a 21-day window surrounding issuance. From days -10 to -6, CARs for both certificated and non-certificated issuers are close to zero, and the differences in CARs between two groups are negligible. Beginning on day -5, the returns for certified green bonds progressively diverge from those of non-certified bonds, probably because the information of green bond issuance is leaked prior to the official announcement. Overall, the figures suggests that the market reactions to green bond announcements are negligible in the period earlier before the announcement and the differences of CARs between certified and non-certified issuers become significant only when the issuance and third-party certification are available to the market, indicating that third-party certification is a causal factor in explaining the market valuation of green bond issuances.



Panel A: event study plot for the cumulative abnormal return with the market-adjusted model

Panel B: event study plot for the cumulative abnormal return with the Fama-French three-factor model

Figure 5.1 Cumulative abnormal return surrounding the certification announcement

This figure examines stock price movements before and after the certification announcement. This study uses the market-adjusted model and Fama-French three-factor model to calculate the abnormal return. CARs are multiplied by 100.

Panel A of Table 5.4 reports the multivariate regression results. Columns (1) and (2) report the results for the CARs from the market-adjusted model and the FF3, respectively. The coefficients of Certified are 2.63 and 3.34, which are significant at the 5% and 1% levels, respectively. Column (3) shows that in the comparison with non-certified green bonds, the BHARs of certified green bonds increase by 8.05%, which is positive and significant at the 10% level. These findings further support Hypothesis 1, which posits that the issuance of certified green bonds enhances company value.

A potential concern is the endogenous selection of companies receiving certification. Larger and financially stronger firms are more likely to obtain certification, and these factors may independently influence market reactions. Therefore, we employ instrumental variable approach to further investigate whether the positive market reaction associated with certified green bonds is partly attributable to characteristics inherent in firms pursuing certification. Companies that issue green bonds need to select an external agency before their green bond issuances, and the potential connection between companies and certification entities plays a crucial role in the certification process. Provinces with a larger number of certification agencies or closer proximity to these entities are more likely to have more certified companies that can access certification services than provinces where access is limited by distance or small numbers of such agencies. The number of eligible certification agencies in a province where a firm is headquartered could increase the firm's probability of receiving third-party certification for green bond issuances; however, the number may not affect corporate performance directly. Therefore, we count the number of certified companies in each province where the green bond issuing companies are located based on the list of certified companies produced by the Green Bond Standards Committee. The geographical distribution of green bond issuing companies and certification companies is presented in Figure 5.2.[18]

[18] Firms located in the provinces with more certification agencies are more likely to receive a third-party certification for their green bond issuances. Moreover, the analysis reveals that the number of green bond certification companies does not directly impact the information asymmetry, greenwashing behaviour and sustainability performance of green bond issuing companies. This finding aligns with the exogeneity assumption, supporting the validity of the instrumental variable approach.

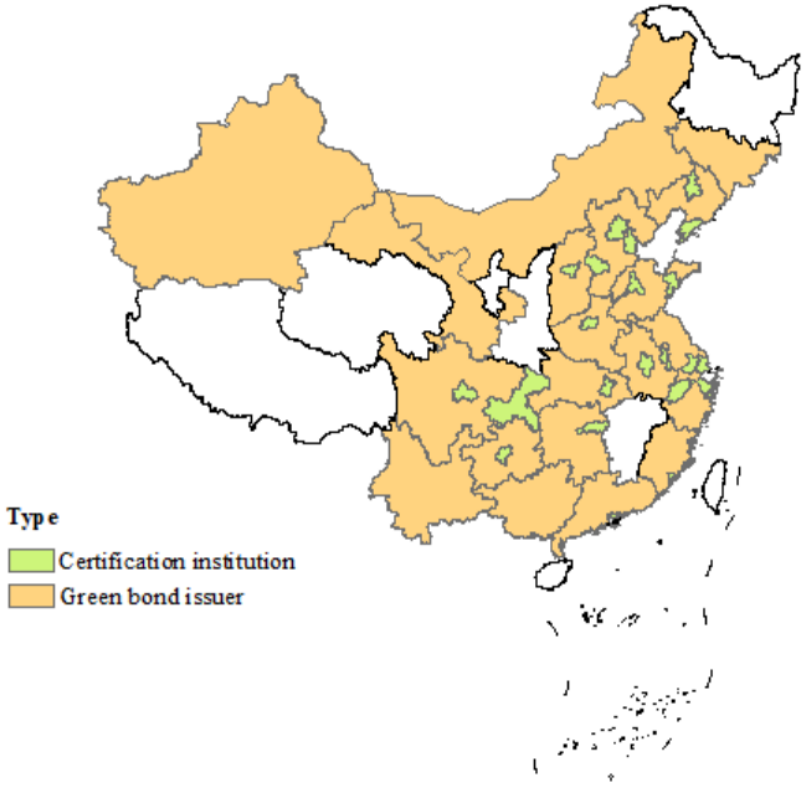


Figure 5.2 The geographical distribution of green bond issuers and certification agencies

Panel B of Table 5.4 shows the results of instrumental variable regression for event studies. This study employs the 2SLS regression analysis and use the number of certification agencies in the province where the green bond issuing companies are located as the instrumental variables for issuing certified green bonds. Column (1) shows that the coefficient on the instrumental variable is positive and highly significant. In addition, the results suggest that firms with larger leverage ratio, smaller firm size, and greater peer certification ratio are more likely to obtain a third-party certification on their green bond issuances. The coefficients on ROA, sales growth, cash ratio and state ownership are positive but insignificant. The coefficients of Label in columns (2) - (4) from the regressions in the second stage remain positive and significant. These results suggest that upon addressing endogeneity concerns, the issuance of certified green bonds generates a substantial and statistically significant stock market response in the short and long term. Therefore, the event study results are robust

Table 5.4 Green bond certification and market reaction to green bond issuance

Panel A: OLS results

	(1)	(2)	(3)
Dep. Var. =	CAR1	CAR2	BHAR
Label	2.63**	3.34***	8.05*
	(2.10)	(2.67)	(1.88)
LEV	15.71*	11.69	1.40
	(1.97)	(1.54)	(0.05)
ROA	42.70	-14.49	-228.04**
	(0.84)	(-0.31)	(-2.06)
SIZE	0.84	0.33	5.19***
	(1.38)	(0.51)	(2.92)
CASH	4.17	-2.50	-185.38***
	(0.32)	(-0.18)	(-3.30)
GROWTH	0.52	0.06	0.31
	(0.74)	(0.08)	(0.13)
SOE	-1.61	-1.78	3.74
	(-0.91)	(-0.98)	(0.77)
PCR	-1.42	-1.25	-10.64
	(-0.47)	(-0.41)	(-0.79)
Constant	-25.84**	-13.52	-76.65**
	(-2.13)	(-1.06)	(-2.24)
Industry Fixed Effect	Yes	Yes	Yes
Observations	203	203	203
R-squared	0.1518	0.1137	0.2565

Panel B: results from the instrumental variable approach

Dep. Var. =	(1) Label	(2) CAR1	(3) CAR2	(4) BHAR
LNTPC	0.20***			
	(4.96)			
Label (instrumented)		6.15*	6.54*	26.26*
		(1.74)	(1.85)	(1.71)
LEV	0.82*	12.85*	11.11	-20.74
	(1.80)	(1.84)	(1.50)	(-0.76)
ROA	0.16	6.53	-1.13	-245.24*
	(0.06)	(0.12)	(-0.02)	(-1.83)
SIZE	-0.22***	0.83	1.04	8.63**
	(-5.48)	(0.84)	(1.06)	(2.30)
CASH	0.46	-12.74	-15.56	-280.37***
	(0.41)	(-0.77)	(-0.91)	(-5.06)
GROWTH	0.04	-0.36	-0.25	-0.18
	(0.98)	(-0.53)	(-0.35)	(-0.07)
SOE	0.07	-2.24	-2.07	5.38
	(0.66)	(-1.26)	(-1.13)	(1.05)
PCR	1.17***	-3.64	-4.37	-31.59
	(5.82)	(-0.74)	(-0.90)	(-1.49)
Constant	3.97***	-26.38	-31.02	-113.03
	(4.95)	(-1.29)	(-1.53)	(-1.49)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Observations	203	203	203	203
R-squared	0.4629	0.1613	0.1694	0.2858
Kleibergen-Paap rk LM statistic		22.48***	22.48***	22.48***
Cragg-Donald Wald F statistic		17.30	17.30	17.30

This table reports results from multivariate analysis (Panel A) and instrumental variable approach (Panel B) for the green bond certification and market reaction. In Panel B, the Cragg–Donald Wald F statistic is much larger than the critical value of the Stock–Yogo weak ID test (16.38), which indicates that the instrumental variable is not weak. The instrumental variable (LNTPC) is the natural logarithm of the number of certification agencies in the same province. In Panels A and B, CARs are short-term market reactions calculated by the market-adjusted and Fama-French three-factor models. BHAR is the buy-hold abnormal return in 12 months after the green bond issuance, calculated by the difference of cumulative raw returns and the corresponding cumulative expected return. Label is a dummy variable equal to one if a green bond is certified by a third party and zero otherwise. Firm-level control variables include ROA, firm size, cash, leverage, sales growth, state ownership, and peer certification ratio. Industry fixed effect is included in the sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

In Table 5.5, this study examines the heterogeneity of certified green bonds. Panel A reports that the market valuation of green bonds certified by a professional certification institution is large and significant, whereas those certified by accounting and auditing companies result in small and non-significant market valuations. Professional certification parties, such as Lianhe Equator, a well-known professional green bonds assessment and certification institution in China, adhere to international standards as methodological guidance and use independently developed green bond assessments and certification methods to ensure the standardisation of green bond certification processes. They have professional environmental knowledge and are able to calculate the environmental benefits associated with green bond investments independently. Therefore, professional certification parties offer unique advantages over accounting companies, which may only verify the numbers provided by green bond issuers. In Panel B, this study investigates the market valuation of the different types of certified green bonds and find that the CARs and BHARs of certified green bonds are only significant in the case of non-financial green bonds. Despite the engagement of third-party certification, investors may encounter challenges in establishing a direct connection between green bonds issued by financial institutions and specific green investment projects (Fatica et al., 2021). Thus, the market exhibits a limited response to certified financial bonds.

Table 5.5 Cross-sectional heterogeneity

	Obs.	CAR1	t-stat	CAR2	t-stat	BHAR	t-stat
Professional vs. auditor:							
Professional certification agencies	90	1.70*	(1.75)	1.36	(1.54)	8.89***	(3.02)
Accounting companies	18	0.22	(0.27)	1.46	(1.72)	6.66	(1.29)
Financial vs non-financial:							
Certified financial green bonds	27	-0.72	(-0.86)	0.64	(0.71)	4.37	(1.05)
Certified non-financial green bonds	80	2.22**	(2.10)	1.64*	(1.70)	9.97***	(3.13)

This table reports the CARs and BHAR for certificated green bonds with different characteristics, including whether green bonds that are certified by a professional certification agency or an accounting & auditing firm, and whether certified green bonds that are financial green bonds or non-financial green bonds. The CARs and BHAR are multiplied by 100. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

5.4.2. Potential mechanisms

In Section 5.4.1 above, this study analysed the market valuation of green bond issuance announcements and found that third-party certification increases the market valuation of green bond issuers. In this section, this study investigates the mechanism of third-party certification in improving the market valuation of green bond issuers. First, this study examines whether the issuance of certified green bonds reduces information asymmetry. This study uses *SYNCH* to assess the information asymmetry (Chan and Hameed, 2006). The DID regression result for the information asymmetry channel is presented in Column (1) of Table 5.6. The coefficient of *Certified*Post* is -0.17, which is negative and significant at the 5% level. This result indicates that stock price synchronicity decreases for the green bond issuers after they issue certified green bonds compared with the issuers of non-certified green bonds. Third-party agencies disclose the use of raised funds and the environmental benefits of green projects supported by certified green bonds, as well as other firm-level information, to the capital market before and after green bond issuance (Ehlers and Packer, 2017). The certification of green bonds provides credible company-specific information to the market and hence reduces the stock price synchronicity of green bond issuers (Duarte-Silva, 2010; Gul et al., 2010).

Next, this study tests the second channel to determine whether third-party certification reduces greenwashing in green bond issuers. Column (2) of Table 5.6 presents the results, showing that green bond certification significantly reduces the corporate greenwashing index measured by the difference between ESG disclosure and actual ESG performance. This finding indicates that third-party certification can deter greenwashing behaviours by green bond issuers and induce them to ‘walk the talk’ – to put their words into action – in reality.

The environmental performance channel demonstrates that the issuance of third-party certification encourages companies to conduct genuine environmental efforts and hence enhance their ESG performance (Hebb et al., 2010; Testa et al., 2018). Column (3) of Table 5.6 shows that ESG ratings significantly increase subsequent to the third-party certification of green bond issuers. Specifically, the coefficient of *Certified*Post* in Column (3) of Table 5.6 is 0.26, which is statistically significant at the 1% level, roughly corresponding to one fifth of a rating grade. This finding aligns with Flammer (2021) that companies proactively enhance their ESG performance following the issuance of certified green bonds. Overall, the analysis suggests that third-party certification of green bond issuance does indeed generate real impacts on the corporate information environment and induces genuine environmental efforts and ESG performance.

Table 5.6 Green bond certification effect: channel analysis

	(1) SYNCH	(2) GW	(3) ESG
Certified * Post	-0.17**	-0.35***	0.26***
	(-2.11)	(-3.30)	(2.85)
Certified	0.11**	0.40***	-0.00
	(2.07)	(6.98)	(-0.10)
Post	0.09	0.20***	-0.01
	(1.34)	(2.65)	(-0.13)
VOLUME	0.05*		
	(1.76)		
VOL	1.43		
	(0.59)		
LEV	0.40**	0.85***	-1.00***
	(2.37)	(4.21)	(-5.88)
ROA	3.70***	-1.01	3.44***
	(4.68)	(-1.03)	(3.52)
SIZE	0.14***	0.06**	0.38***
	(5.60)	(2.05)	(17.24)
CASH	0.54	-0.42	-2.54***
	(1.45)	(-0.99)	(-6.09)
GROWTH	0.02	0.00	-0.05*
	(0.78)	(0.07)	(-1.95)
SOE	-0.12**	-0.03	0.05
	(-2.12)	(-0.35)	(1.10)
PCR	0.07	0.55	-0.37
	(0.27)	(1.43)	(-1.32)
Constant	-3.04***	-1.84***	-0.90**
	(-6.48)	(-3.74)	(-2.35)

Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	2,919	2,466	2,921
R-squared	0.3356	0.1406	0.3043

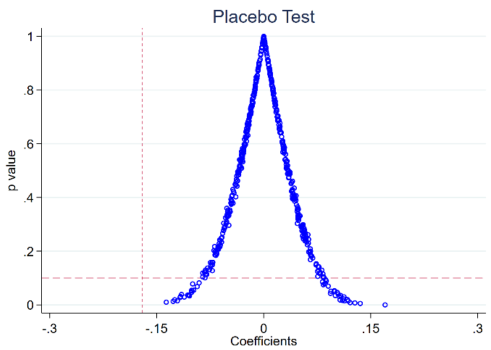
This table reports the channels through which third-party certification in green bond issuance can benefit issuers from a firm-quarter sample. SYNCH is calculated from the R-squared estimate in Equation (1). It is a proxy of information asymmetry. GW is measured by the difference between a firm's Bloomberg ESG disclosure and its Huazheng ESG rating, a proxy of greenwashing. ESG is the ESG rating score published by Huazheng. It is a proxy of environmental performance. Certified is a dummy variable for green bond issuers with any certificated green bond in the sample. Post is a dummy variable that indicates whether observations are made after the certification. Firm-level control variables include ROA, firm size, cash, leverage, sales growth, state ownership, peer certification ratio, trading volume, and stock return volatility. Industry and year fixed effects are included in the sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

5.4.3. Robustness tests

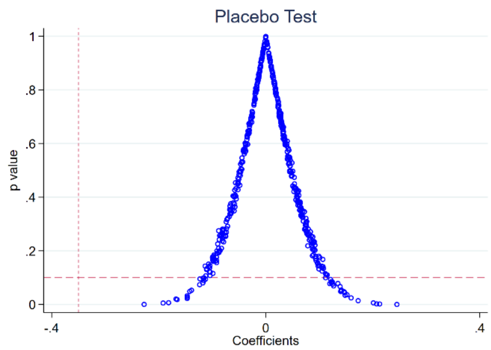
Placebo tests

Results suggest that green bond certification can provide certification value to companies by reducing information asymmetry, preventing greenwashing behaviour and enhancing corporate sustainable performance. However, it is essential to acknowledge that the observed certification values may be influenced by other unobservable random factors. To ensure the accuracy of the estimates, this study follows the approach outlined by Liu et al. (2022) and constructs a placebo test by randomly fabricating a treatment group that has issued certified green bonds and a group that has not issued certified green bonds. Specifically, this study randomly assigns green bond issuers as the treatment group, assuming that these issuers have issued certified green bonds. The other green bond issuers form the control group on the assumption that these issuers have never issued certified green bonds. To validate the results, this study re-estimates the benchmark model (5.5) using the new samples 500 times.

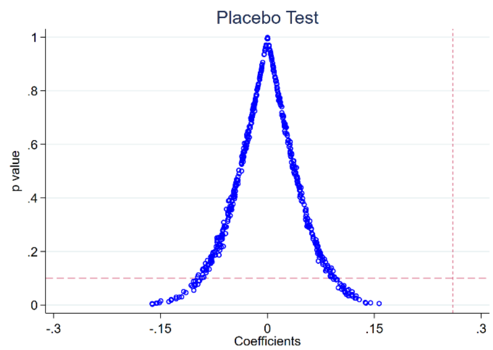
Figure 5.3 illustrates the distribution of the 500 estimated coefficients and the corresponding p values for the interaction term, *Certified*Post*. In Figure 5.3, the estimated coefficient is plotted along the x-axis, while the *p-value* is depicted along the y-axis. Each data point on the graph corresponds to a pair of observations of the estimated coefficient and its associated *p*-value. Figure 5.3 shows that the estimated coefficients are grouped predominantly around zero, with most estimates having *p*-values greater than 0.1 (not significant at the 10% level). Furthermore, the baseline estimates presented in Table 5.6 fall outside the range of coefficients obtained from the simulation exercise. These findings suggest that it is unlikely that the channel analysis results are attributable to chance and are therefore unlikely to be affected by random factors. Consequently, these findings support the conclusion that the certification value arises from the reduction of information asymmetries, the consistent avoidance of greenwashing through the issuance of third-party certified green bonds and improvements in sustainability performance.



Panel A: Placebo test for the information asymmetry channel



Panel B: Placebo test for the greenwashing prevention channel



Panel C: Placebo test for the environmental performance channel

Figure 5.3 Placebo tests

Figure 5.3 reports the placebo test results by randomly fabricating experimental group. This study runs placebo tests by re-estimating the model Eq.(5.5) for SYNCH, GW and ESG separately in 500 random samplings.

Entropy balancing approach

Another concern is that green bond issuers with third-party certification could differ substantially from green bond issuers without such certification. In this section, this research employs the entropy balancing approach to validate the robustness of the mechanism analysis. Hainmueller (2012) proposes the entropy balancing method to control for the multidimensional balance of covariates between treatment and control groups. This study follows Hainmueller (2012) in performing a balance test on the covariates of the treatment group and the control group to ensure that the experiments are random or exogenous to enhance the validity of the mechanism analysis. This study considers the first, second, third and cross moments of the covariates to ensure that the matching is highly accurate.

Panel A of Table 5.7 provides the entropy balancing results. Column (1) shows a negative and significant coefficient on the interaction term *Certified*Post*. These results indicate that the disclosure of detailed firm information as a result of third-party certification, such as financial and project investment information, mitigates information asymmetry in relation to green bond issuers. The coefficient of the interaction term in Column (2) is -0.27, which is significant at the 1% level, which adds credence to the greenwashing prevention channel – that is, that third-party certification and supervision of green bond issuances can prevent corporate greenwashing strategies. The coefficient of the interaction term *Certified*Post* in Column (3) is positive and significant, indicating that firms improve their ESG performance following the issuance of certified green bonds. Therefore, the results of the entropy balancing approach verify that the mechanism analysis is robust.

Reconstruction research sample

One remaining concern is the potential collusion between green bond issuers and third-party certification agencies, leading to the dissemination of false information to the capital market (Gentzkow and Shapiro, 2006; Duong et al., 2021; Goldman et al., 2022). To address this issue, this research reconstructs research sample to test the consequences of green bond issuances. This study sourced detailed information on the certification agencies from Qichacha, a leading platform that provides comprehensive company information in China and removed certified green bond issuers that are controlled by equity holders of certification agency. This study also eliminated certified green bond issuers in cases in which the certification agency and the issuers' accounting agency were the same institution. After excluding samples that may involve collusion between green bond issuers and third-party certification institutions, this study re-evaluates the results. Panel B of Table 5.7 presents these findings, which remain statistically significant even after this study implements these adjustments.

Instrumental variable regression

Some omitted factors may affect both the probability of receiving a third-party certification and a firm's information transparency, greenwashing and environmental performance. To mitigate the potential bias stemming from endogeneity, this study employs the IV approach to perform a robustness test. This study employs the instrumental variable constructed in Section 5.4.1. The results of the instrumental variable regression for the channel analysis are shown in Panel C of Table 5.7. This study interacts the instrumental variable with the *Post* variable and use the interaction variable as the new instrumental variable for the channel analysis. Industry and year fixed effects are controlled, and the results in Columns (2) and (3) demonstrate that after endogeneity bias is eliminated, the issuance of certified green bonds significantly affects both corporate information asymmetry and greenwashing behaviour, with a consistently negative influence. The impact remains significant and negative. The results in Column (4) indicate a significant increase in sustainability performance. Therefore, the instrumental variable approach confirms the robustness of these results.

Table 5.7 Robustness test

Panel A: Entropy balancing approach

	(1) SYNCH	(2) GW	(3) ESG
Certified*Post	-0.37**	-0.27***	0.74***
	(-2.48)	(-2.63)	(5.83)
Certified	0.24*	0.06	0.09
	(1.84)	(0.92)	(1.27)
Post	0.21	0.05	-0.71***
	(1.34)	(0.58)	(-5.92)
Constant	-3.74***	-2.72***	-2.04***
	(-3.80)	(-4.90)	(-3.24)
Firm Control	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	2,919	2,466	2,921
R-squared	0.3006	0.1359	0.4771

Panel B: Reconstruction research sample

	(1) SYNCH	(2) GW	(3) ESG
*Certified*Post*	-0.18**	-0.39***	0.27***
	(-2.26)	(-3.61)	(2.92)
Certified	0.12**	0.45***	-0.00
	(2.27)	(7.69)	(-0.01)
Post	0.09	0.21***	-0.03
	(1.46)	(2.75)	(-0.41)
Constant	-2.93***	-1.90***	-0.78**
	(-6.17)	(-3.80)	(-2.04)
Firm Control	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	2,827	2,386	2,829
R-squared	0.3277	0.1462	0.2918

Panel C: Instrumental variable regression for channel analysis

	(1)	(2)	(3)	(4)
Dep. Var. =	*Certified*Post*	SYNCH	GW	ESG
LNTPC*Post	0.04***			
	(3.23)			
Certified*Post (instrumented)		-2.27**	-0.88*	2.62**
		(-2.15)	(-1.66)	(2.09)
Constant		-3.19***	-1.61***	-2.22**
		(-5.72)	(-2.91)	(-3.99)
Firm Control		Yes	Yes	Yes
Industry Fixed Effect		Yes	Yes	Yes
Year Fixed Effect		Yes	Yes	Yes
Observations		2919	2466	2921
R-squared		0.0850	0.1276	0.2340
Kleibergen-Paap rk LM statistic		10.36***	26.67***	11.18***
Cragg-Donald Wald F statistic		22.92	80.62	29.78

This table reports the robustness result by using the entropy balance approach (Panel A), reconstruction research sample (Panel B) and instrumental variable method (Panel C). In Panel C, the Cragg–Donald Wald F statistic is much larger than the critical value of the Stock–Yogo weak ID test (16.38), which indicates that the instrumental variable is not weak. We interact *LNTPC* with the *Post* variable and use the interaction variable (*LNTPC*Post*) as the instrumental variable for the channel analysis. In Panels A-C, *SYNCH* is calculated from R-squared in a market model. GW is measured by the difference between a firm's Bloomberg ESG disclosure and Huazheng ESG rating. ESG is the firm's ESG rating, published by Huazheng and converted into a score. *Certified* is a dummy variable for green bond issuers with any certificated green bond in the sample, and *Post* is a dummy variable that indicates whether observations are after the certification or not. Firm control is a set of firm-level control variables, including the ROA, firm size, cash, leverage, sales growth, state ownership, peer certification ratio, trading volume, and stock return volatility. Industry and year fixed effects are included in the sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

5.4.4. Further analysis: Institutional ownership, analyst and regulator attention

In this section, this study reports additional results regarding institutional ownership, analyst coverage and the regulator's assessment, which provide further support for the argument above that third-party certification can generate real economic and environmental benefits for green bond issuers. If third-party certification can reduce information asymmetry, prevent greenwashing and improve environmental performance, it is expected that green bond issuers that receive third-party verification will attract more analysts and long-term investors who value sustainability than before green bond certification (Tang and Zhang, 2020; Flammer, 2021). Column (1) of Table 5.8 displays the results for long-term institutional ownership. The results indicate a 1.96% increase in long-term institutional investor participation following certified green bonds issuance. Columns (2) and (3) show that the analyst coverage and information disclosure ratings assessed by the regulator both increase significantly among the green bond issuers subsequent to third-party certification. After the issuance of certified green bonds, the analyst coverage and information disclosure ratings increase by 25.86% and 0.58, respectively. The increase in analyst attention and the improvement in disclosure quality perceived by the regulator could be attributed to third-party certification inducing an increase in information disclosure by green bond issuers. Overall, the further analysis suggests that improved information transparency and environmental performance do help green bond issuers to attract institutional investment, increase their analyst coverage and enhance the regulator's opinion of their disclosures subsequent to third-party verification.

Table 5.8 Green bond certification effect: institutional ownership, analyst coverage and carbon emission performance

	(1) LTIO	(2) ANACOV	(3) IR	(4) Carbon intensity
*Certified*Post*	1.96**	0.23**	0.58**	-0.04***
	(2.17)	(1.97)	(2.44)	(-3.06)
Certified	0.72	-0.03	-0.37*	0.04***
	(1.00)	(-0.36)	(-1.95)	(4.64)
Post	-0.00	-0.17	-0.64***	0.03***
	(-0.00)	(-1.54)	(-3.30)	(3.22)
Constant	-15.54***	-9.16***	3.53***	-0.19***
	(-2.76)	(-16.21)	(3.70)	(-2.67)
Control variables	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	777	777	777	615

R-squared	0.3511	0.6731	0.4675	0.3213

This table reports the additional benefit for green bond issuers from issuing the third-party certification green bond. We construct a firm-year sample of green bond issuers to explore the additional benefit of third-party certification. LTIO is measured by the ratio of the number of shares held by long term institutional investors to the total number of shares. The variable is multiplied by 100. ANACOV means the log of the number of analysts following the company within a year. IR refers to the information disclosure rating published by the CSRC. Carbon intensity as a firm's total scope1 and scope2 emission divided by its market capitalization. *Certified* is a dummy variable for green bond issuer with any certificated green bond in the sample and *Post* is a dummy variable to indicate whether observations are after the certification or not. Firm control is a set of firm level control variables, including the ROA, firm size, cash, and leverage. Industry and year fixed effects are included in the sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10

5.4.5 The carbon emission performance for issuing certified green bond

In this section, this study investigates whether third-party certification in green bond issuances can reduce carbon emission. Column (4) of Table 5.8 reports the DID estimation result for certified green bond issuance and carbon emission performance from 2014 to 2022. Corporate carbon emission performance is measured by the scope1 and scope2 emission divided by its market capitalization , following Ramelli et al. (2021). The coefficient of *Certified*Post* is -0.04 and significant at 1% level. Third-party certification can result in a 4% decrease in firm carbon intensity. This indicates that such certification facilitates the allocation of green funds to projects that enhance environmental protection and sustainable development, thereby preventing greenwashing and genuinely improving environmental performance. This evidence further supports hypotheses H2c.

5.5. Conclusions

This study examines the real impacts of third-party certification in green bond issuances in China, assessing the benefit of market-driven incentives for corporate green transformation. To the best of knowledge, this is the first comprehensive analysis that thoroughly investigates the value of third-party certification in green bond issuance. The results show that third-party certification in green bond issuance enhances firm value in both a short-term window surrounding the announcement of green bonds and in the long term after the issuance. This study explores three potential channels through which third-party certification can benefit firms and thereby increase market valuations. The empirical evidence shows that certification reduces information asymmetry, prevents corporate greenwashing and increases environmental performance more effectively for green bond issuers than for uncertified green bond issues. Moreover, the additional testing reveals that the issuance of certified green bonds attracts more long-term institutional investors, garners increased coverage from analysts and enhances the positive opinions of the regulator compared with companies issuing non-certified green bonds because of the economic and environmental benefits to issuers. Carbon emissions performance is improved by the certification among green bond issuers. Overall, this research highlights market-based instruments have the potential to facilitate corporate green transformation and enhance firm value. This research contributes to the growing body of literature on green bonds, environmental certification value and environmental governance. This study demonstrates that third-party certification in green bond issuance has significant and real effects and that it increases firm value.

Chapter 6. Conclusions

6.1. The achievement of research objectives and major findings

The dissertation addresses two major research objectives. The first objective is to evaluate how government-led policy promotes regional and corporate green transformation in China, focusing on exploring unique Chinese characteristics, such as using a cadre evaluation system to promote economic and social goals and the dominance of SOEs in the economic system. Chapters 3 and 4 examine how the cadre evaluation system impacts local governments' decarbonisation practice and whether and how the government can achieve carbon neutrality goals by engaging SOEs. Specific research objectives are as follows:

1. To assess the effectiveness of government target responsibility policy in promoting regional green development;

2. To investigate the impact of state ownership on the achievement of the state's commitment to carbon neutrality goals;

Chapter 3 addresses Objective 1 by investigating the effectiveness of incorporating green targets into the target responsibility system to promote local green building practices. The empirical strategy leverages the staggered implementation of assessment policies across various cities to ascertain its causal effect. The findings indicate that integrating green building targets into the target responsibility system significantly stimulates local green building construction. Furthermore, results demonstrate that the effectiveness of the green building target responsibility system varies with the type of assessment employed. Specifically, incorporating local green building practices into cadre evaluation exerts a stronger positive impact on green building development than integrating them into energy conservation assessments. This highlights the importance of considering diverse evaluation criteria when designing and implementing green transformation policies. Subsequently, the chapter further explores how the target responsibility system contributes to green building practices in regional areas. The system promotes green practices by raising environmental concerns among the government and the public and through financial incentives. Additionally, integrating green targets into the responsibility system enhances green buildings' certification level and reduces the city's carbon footprint. Prior research has investigated the impact of incorporating environmental performance into the performance evaluation metrics of local officials on reducing pollutant emissions (Chen et al., 2018). However, green transformation requires a greater focus on the less observable CO2 emissions. Unlike prior studies, the dissertation investigates how integrating green building targets into the local government's target responsibility system can effectively facilitate the implementation of carbon emission reduction policies. In conclusion, chapter 3 emphasizes the pivotal role of government-led green policies in promoting regional green transformation, thereby fulfilling research objective 1.

To achieve Objective 2, the dissertation investigates whether state ownership is more responsible for carbon neutrality in the context of the country that produces the most carbon dioxide. There has been a debate over whether SOEs outperform non-SOEs regarding environmental performance. Chapter 4 examines listed firms' market reactions to the carbon neutrality commitment for China that was announced for the first time on 22 September 2020. Using the event study method and based on 2,792 listed firms, the dissertation finds that overall market reactions to the carbon neutrality commitment are significantly negative, suggesting that firms are expected to exert genuine efforts towards attaining the national goal of carbon neutrality. Furthermore, results indicate that SOEs encounter more substantial negative market reactions than non-SOEs, indicative of higher expectations for them to realize the commitment to carbon neutrality. Further analysis reveals that negative market reactions are particularly pronounced for central SOEs as opposed to local SOEs, as the former is perceived to bear a heavier responsibility in achieving national goals. Additionally, SOEs with higher corporate social responsibility scores experience stronger negative market reactions than those with lower scores. Further analysis based on a difference-in-differences method and a firm-year sample shows that SOEs reduce firm value and carbon emissions intensity more than non-SOEs after the carbon neutrality commitment. Previous studies have explored the potential of carbon policies to achieve carbon neutrality goals. They indicate that low-carbon pilot policies can significantly improve energy management, reduce carbon emissions, and serve as a viable pathway towards achieving carbon neutrality (Chen et al., 2022; Yu and Zhang, 2021). In contrast to these studies, this dissertation investigates the forces of realizing carbon neutrality commitment and finds that SOEs have assumed a leading role in achieving the country's carbon neutrality goals. Additionally, the dissertation reveals that CSOEs have the potential to expand their responsibilities in this area further. Overall, the dissertation supports the argument that state ownership could be an effective mechanism to achieve national carbon green transformation goals.

The third research objective is to investigate how market-driven instruments stimulate green transformation from a market perspective. Chapter 5 examines the real effects of third-party certification in green bond issuance by Chinese listed firms over the 2016-2022 period to fill the research gap on whether and how firms can benefit from third-party certification. The dissertation first uses the market-adjusted model and FF-3 factors to calculate the cumulative abnormal returns and test the research hypothesis that third-party certification increases the market valuation of green bond issuers. The findings reveal that issuing certified (non-certificated) green bonds results in favourable (insignificant or even negative) stock market reactions in the short and long term, indicating that third-party certificate adds value to stock investors. Additionally, the dissertation employs the difference-in-difference approach to analyse the underlying mechanisms that drive the value creation of third-party certification in green bond issuance. The third-party certification effectively reduces information asymmetries between firms and investors, induces firms to prioritise sustainable practices genuinely, and improves a firm's environmental performance, increasing investor demand and firm value. Further analysis reveals that third-party certification helps green bond issuers attract long-term investors, increase analyst coverage, and induce positive opinions on disclosure from regulators. Carbon intensity is reduced more when green bond issuers are certified. Prior studies have examined whether green bond issuance results in a positive market reaction, lower capital cost, and environmental solid signalling commitment (Zerbib, 2019; Larcker and Watts, 2020; Tang and Zhang, 2020; Flammer, 2021; Pástor et al., 2022). The dissertation is the first to investigate the real impacts of third-party certification of green bonds on corporate green transformation. This chapter documents that market-driven instruments can facilitate corporate green transformation, generate real economic and environmental benefits for issuers, and achieve this research objective.

6.2. Policy implications

The dissertation has identified the effectiveness of government-led initiatives in facilitating green transformation. Chapter 3 reveals that although the government's target responsibility system has resulted in greater adoption of green buildings, overall development remains limited in China. The existing policy vaguely proposed the direction of green transformation without definitive legislative support or specific quantitative targets. Promoting green buildings as an extension of energy conservation in construction has been ongoing for over a decade. Therefore, it is necessary to swiftly enact laws to address the deficiencies in the current legal system. Incorporating green transformation into the assessment of local officials has proven effective. Therefore, the government should establish transparent and quantifiable objectives and incorporate these goals into the cadre evaluation system to ensure proactive local government responses to the green transformation initiative.

Chapter 3 indicates that green building projects in China are primarily financed by the government, with little input from the private sector. A synergy of market instruments and government policies is necessary to promote private sector participation in green transformation. The financial institutions can offer green loans tailored to green building projects with competitive interest rates and flexible repayment terms to attract private developers. Furthermore, the government can help developers issue green bonds to finance these initiatives. Green bonds should be specifically designated for constructing and improving green buildings. The projects' green attributes of these bonds can be evaluated and certified by independent third-party agencies to attract more investors to the green building market.

The green transformation will not be achieved overnight. In Chapter 4, the findings indicate that the government should strengthen its supervision of SOEs to encourage their active participation in pollution and carbon emission reduction efforts. It is imperative to establish a carbon emission data disclosure platform for SOEs, with obligatory data disclosure and strengthened review processes. In addition, energy conservation and carbon reduction should be incorporated into the performance assessment system of SOEs. Penalties and sanctions should be imposed on SOEs that fail to meet the standards to prevent superficial green efforts. These measures will enable SOEs to optimize their energy structures and reduce reliance on highly polluting and high-carbon emission energy sources.

Although Chapter 4 emphasizes that SOEs are more responsible for carbon neutrality than non-SOEs, the role of private-owned enterprises (POEs) in green transformation should not be overlooked. POEs significantly contribute to the economy, accounting for over 50% of tax revenues, more than 60% of GDP, and over 70% of technological innovations. However, the allocation of financial resources in the Chinese market is not necessarily determined by the quality and financial status of firms, with banks showing a preference for lending to SOEs (Cull and Xu, 2003). The green transformation is estimated to require approximately 139 trillion. A mismatch of financial resources poses a severe obstacle to POEs securing financing, resulting in high financing costs that impede their ability to meet the substantial demand for green transition funding. The government can mitigate this issue by providing financial support, including venture capital, green funds and tax preference, to assist POEs in achieving carbon neutrality. Further, the government should encourage banks and financial institutions to offer green loans and preferential interest rates to POEs.

Chapter 5 demonstrates that companies' self-environmental certification behaviours can help bridge the information gap between companies and investors, ensuring genuine compliance with environmental commitments instead of greenwashing. This attracts investors and increases corporate value. Therefore, the corporate green transformation system could be constructed in a market-led and government-supplemented manner to enhance corporate environmental certification behaviours. China could leverage third-party certification to establish a robust and credible sustainable financial ecosystem, attracting more investors, promoting positive environmental impacts, and accelerating the green transformation. However, the cost of third-party certification may pose a barrier for some issuers, notably smaller or capital-constrained projects. To promote broader participation in sustainable finance, it is crucial to ensure that certification is affordable and accessible to a wide range of issuers. Therefore, while developing market-based environmental resource allocation mechanisms, governments should provide financial support for voluntary corporate environmental initiatives. This support will help issuers afford certification costs and further encourage positive corporate actions on environmental protection.

The dissertation also provides recommendations for market investment. Regulatory frameworks, economic transformation paths, and the physical impacts of climate change will alter investment risks. Investors should exercise caution to minimize potential losses. Chapter 4 reveals that SOEs play a significant role in green transformation, resulting in short-term financial losses and adverse market reactions. As a result, investors should consider the type of corporate ownership and assess the impact of environmental policies on stock performance. Chapter 5 proves that the market rewards firms that genuinely address climate change. Therefore, investors should identify firms' authentic commitment to the environment to prevent greenwashing and avoid investment losses. Several companies claim to be adopting green practices to fulfil their environmental and societal responsibilities in light of the global focus on sustainable development. However, some firms may exploit this trend by promoting false propaganda and greenwashing for unjustified financial gain. Investors need to strengthen their due diligence and carefully evaluate the green transformation actions of firms to ensure their authenticity and sustainability. Independent third-party certification and rating agencies can provide impartial insights. By identifying firms genuinely committed to green transformation, investors can mitigate the risks of false green propaganda and ensure sustainable and profitable investments.

6.3. Limitation and further research directions

The dissertation investigated the force of Chinese government-led mechanisms and market-driven instruments in facilitating green transformation in China and provided research results, as shown above. This section offers some insights into future research.

The dissertation examines how government-led policies and market-driven instruments can facilitate the transition to a green economy. Public participation in environmental governance is widely recognized as essential for exerting pressure on regulators and improving government accountability. However, the dissertation insufficiently addresses the public's role in the green transformation. Public involvement in environmental protection can mitigate government administrative and enforcement costs. For example, social media-facilitated reporting of illegal pollution has effectively reduced corporate emissions. Despite minimal costs, public endorsement of green values has yielded substantial environmental benefits and can stimulate the growth of green businesses, thereby advancing the green transition. Although research on public participation in green transformation remains nascent, a comprehensive green transformation model must consider the influence of the public and NGOs. Consequently, future research should investigate the role of public participation in green transition modelling.

The dissertation highlights the constraints government-led policies impose on the green transformation of local governments and SOEs through target responsibility systems and state ownership. However, government-led policies are poorly understood regarding their impacts on private firms' green transformation decisions. A critical issue in this context is whether private firms' efforts to promote sustainable development compromise their values. Consequently, it is imperative to examine the specific strategies employed by private firms in response to the green transition and to assess their impact on firm values. Additionally, it is necessary to determine whether these strategies genuinely reflect a green transition or merely constitute superficial greenwashing. These topics will be addressed in further studies.

The dissertation demonstrates that market mechanisms can enhance firms' value and environmental performance. However, the influence of market mechanisms on business decisions remains unclear. In addition, the findings indicate that government-led green policies have not sufficiently motivated the private sector to develop green buildings, resulting in slow progress. This suggests that government intervention alone is inadequate for promoting firm environmental sustainability actions. Therefore, the role of market mechanisms in promoting green building development should be explored in future research. Specifically, it is essential to empirically test how market instruments, such as social capital concerns, influence firms' decisions to adopt environmentally responsible practices.

Appendices: Supplementary Information

Appendix of Chapter 3

A1: The definition for variable

GB	Dummy variables, equal to one if the land is transferred to build green building and zero otherwise.
Ranking	Green building certification level. The green building includes three level.
Public	Dummy variables, equal to one if the land is transferred to build public green building and zero otherwise.
Residential	Dummy variables, equal to one if the land is transferred to build residential green building and zero otherwise.
Commercial	Dummy variables, equal to one if the land is transferred to build commercial green building and zero otherwise.
Post	is one for years after the green building development policy implementation.
Treat	Dummy variables, equal to one if the city implements government responsibility target assessment on the development of green buildings and zero otherwise.
Promotion	Dummy variables, equal to one if it has been included in the cadre assessment after the green building assessment policy is promulgated and zero otherwise.
Non-promotion	Dummy variables, equal to one if it hasn't been included in the cadre assessment after the green building assessment policy is promulgated and zero otherwise.
Energy	Dummy variables, equal to one if it has been included in the assessment of government energy-saving targets after the green building assessment policy is promulgated and zero otherwise.
Non-energy	Dummy variables, equal to one if it hasn't been included in the assessment of government energy-saving targets

	after the green building assessment policy is promulgated and zero otherwise.
Land area	The log of land transfer area for parcel-level land.
LTA	Dummy variable, equal to one if land transfer methods are listing, tender and auction and zero otherwise.
Price	Dummy variables, equal to one If the land is transferred for a fee and zero otherwise.
Land Type	Dummy variables, equal to one if the land types are residential and commercial and zero otherwise.
GDPGROWTH	Gross domestic production (GDP) growth rate.
GDPPER	The log of gross domestic production (GDP) per capita.
Investment	The log of fixed asset investment.
Deficit	(Municipal fiscal revenue-expenditure)/ to GDP.
POPGROWTH	Population growth rate.
Government Environmental Attention	The ratio of the frequency of environment-related words mentioned in the government work report to the total frequency of words.
Public Environmental Concern	The annual index of the public's use of Baidu for environment-related searches.
Financial Incentives	Dummy variable, equal to 1 when the government provides financial support for green buildings and 0 otherwise.
Carbon Intensity	Urban carbon emissions divided by GDP.

Appendix of Chapter 4

B1: The definition for variables

Variables code	**Variable name and definition**
CAR1	The cumulative abnormal return calculated from the market model
CAR2	The cumulative abnormal return calculated from the market-adjusted model
SOE	State-owned enterprise is a dummy variable equal one if a firm is owned by state or a state-controlled institution, and zero otherwise.
LSOE	Local state-owned enterprise is a dummy variable equal one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise.
CSOE	Central state-owned enterprise is a dummy variable equal one if a firm is controlled by central government or a central state-controlled institution, and zero otherwise.
CSR	Corporate social responsibility score.
MOM	Past stock return in the last 90 trading days.
TOBINQ	Firm market capitalization plus book value of liabilities as a ratio of total assets.
Carbon Intensity	Firm's total carbon emissions (scope1, scope2 and scope3) divided by market capitalization.
LEV	Leverage ratio, calculated by total debt over the total asset in a firm in a year.
CAPEX	Capital expenditure ratio = (Change in property, plant, and equipment + depreciation)/ total assets.
ROA	Return on assets in a firm in a year.
BM	Market to book ratio, calculated by the market value of equity over the book value of equity in a firm in a year.
LNMV	The natural logarithm of market capitalization in a firm in a year.
SALEGROWTH	Sale growth ratio, calculated by comparing the sales revenue of a firm year to the sales revenue of a previous period.
AGE	Natural log of years since the firm's presence in the market.

B2: Additional test for add carbon emissions as control variables

Table B1 SOEs and market reaction to carbon neutrality commitment

	(1)	(2)
	CAR1	CAR2
SOE	-0.34**	-0.33**
	(-2.48)	(-2.47)
EMISSION	-0.06***	-0.05***
	(-3.98)	(-3.62)
Constant	-0.34	-0.41
	(-0.32)	(-0.40)
Control	Yes	Yes
Industry Fixed Effect	Yes	Yes
Provincial Fixed Effect	Yes	Yes
Observations	1508	1508
R-squared	0.0772	0.0779

This table provides the results from multivariate analysis for the state ownership and market reaction. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, LNMV, and EMISSION. The industry and provincial fixed effect are included in this sample. Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Table B2 Central SOEs, local SOEs and market reaction to carbon neutrality commitment

	(1) CAR1	(2) CAR2
CSOE	-0.52***	-0.48***
	(-3.20)	(-3.01)
LSOE	-0.24	-0.24
	(-1.52)	(-1.60)
EMISSION	-0.06***	-0.05***
	(-3.96)	(-3.61)
Constant	-0.54	-0.58
	(-0.51)	(-0.56)
Control	Yes	Yes
Industry Fixed Effect	Yes	Yes
Provincial Fixed Effect	Yes	Yes
Observations	1508	1508
R-squared	0.0786	0.0789

This table provides the results from multivariate analysis for the different state administration affiliations and market reactions. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. *CSOE* is a dummy variable equal to one if a company is controlled by the central government or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, LNMV, and EMISSION. The industry and provincial fixed effect are included in this sample. Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Table B3 Social responsibility, SOEs and market reaction to carbon neutrality commitment

	High CSR Score		Low CSR Score	
	(1)	(2)	(3)	(4)
	CAR1	CAR2	CAR1	CAR2
SOE	-0.27*	-0.27*	-0.36	-0.38
	(-1.68)	(-1.76)	(-1.22)	(-1.30)
EMISSION	-0.06***	-0.06***	1.21	1.40
	(-3.43)	(-3.12)	(1.27)	(1.41)
Constant	-0.09	-0.06	2.02	0.55
	(-0.08)	(-0.05)	(0.62)	(0.17)
Control	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes
Observations	1171	1171	337	337
R-squared	0.0959	0.0931	0.1849	0.2075
Coef. of SOE in High CSR Score group= Coef. of SOE in low CSR Score group	p=0.000	p=0.000		

This table provides the results from multivariate analysis for the state ownership and market reaction to the carbon neutrality commitment with different CSR score. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. The SOE is a dummy variable equal to one if a firm is owned by the state or a state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, LNMV, and EMISSION. The industry and provincial fixed effect are included in this sample. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Table B4 Social responsibility, LSOEs, CSOEs and market reaction to carbon neutrality commitment

	High CSR Score		Low CSR Score	
	(1)	(2)	(3)	(4)
	CAR1	CAR2	CAR1	CAR2
CSOE	-0.47**	-0.44**	-0.41	-0.41
	(-2.46)	(-2.40)	(-1.16)	(-1.15)
LSOE	-0.17	-0.18	-0.33	-0.36
	(-0.93)	(-1.05)	(-1.00)	(-1.13)
EMISSION	-0.06***	-0.05***	1.23	1.41
	(-3.41)	(-3.10)	(1.28)	(1.41)
Constant	-0.33	-0.26	1.93	0.50
	(-0.28)	(-0.23)	(0.58)	(0.15)
Control	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Provincial Fixed Effect	Yes	Yes	Yes	Yes
Observations	1171	1171	337	337
R-squared	0.0973	0.0942	0.185	0.2076

This table provides the results from multivariate analysis for the different state administration affiliations and market reactions to the carbon neutrality commitment with different CSR score. CARs are short-term market reactions, calculated by the market model and market-adjusted model. CARs are multiplied by 100. *CSOE* is a dummy variable equal to one if a company is controlled by the central government or a central state-controlled institution, and zero otherwise. *LSOE* is a dummy variable equal to one if a firm is controlled by a local government or local state-controlled institution, and zero otherwise. Firm-level control variables include the MOM, LEV, CAPEX, ROA, BM, LNMV, and EMISSION. The industry and provincial fixed effect are included in this sample. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Appendix of Chapter 5

C1: Green bonds certified and non-certified: comparison of information disclosure

	Certificated Bond	Non-certificated Bond
Security ID	132280119.IB	111084.SZ
Disclosure documents	Green Bond Legal Opinion	Green Bond Legal Opinion
	Green Bond Credit Rating Report	Green Bond Credit Rating Report
	Green Bond Prospectus	Green Bond Prospectus
	Green Bond Issuance Announcement	Green Bond Issuance Announcement
	Green Bond Issuance Scheme and Commitment Letter	
	Pre-Issuance Independent Evaluation and Certification Report for Green Bonds	
	Ongoing Monitoring and Evaluation Certification Report for Green Bond Tenure	
	Report on the use of green bond funds and progress of green projects	

This table provides the relevant documents related to two green bond issues disclosed their issuers. 132280119.IB is a green bond issued by Contemporary Amperex Technology Co. Limited on 12 Dec 2022 and was certificated by Lianhe Equator Environmental Impact Assessment Co. Ltd. 111084.SZ is a green bond issue by Shenzhen Energy on 24 June 2019, which was not certificated by a third-party agency.

C2: The definition for variables

Variables	Definition
Label	Dummy variable; equals one if a green bond is certified by the third-party, and zero otherwise
Post	Dummy variable; indicated whether observations are after the certification or not
Certified	Dummy variable; for green bond issuer with any certificated green bond in the sample
CAR1	Cumulative abnormal return; calculated by the market-adjusted model
CAR2	Cumulative abnormal return; calculated by the Fama-French three-factor model
BHAR	Buy-hold abnormal return; calculated by the difference of cumulative raw return in 12 months and the cumulative expected return in the corresponding period
LEV	Leverage ratio; the ratio of total debt to total asset
ROA	Return of asset; calculated by dividing net income by total assets
SIZE	Firm size; the logarithm of market value of equity
CASH	Cash ratio; the ratio of cash to total assets
GROWTH	Sales growth ratio; the ratio of the change in sales to lagged sales
SOE	Dummy variable; equals one if a green bond issuer is owned by state or a state-controlled institution, and zero otherwise
PCR	Peer certification ratio; the ratio of green bond issuers (except the focal issuer) that adopt third-party certification in the same region and industry
VOLUME	Trading volume; the total number of shares of a company that were traded in a given quarter divided by the number of shares outstanding
VOL	Stock return volatility; measured by standard deviation of stock returns
LNTPC	The natural logarithm of the number of eligible green bond certification agencies in the same province that a firm locates
SYNCH	Stock price synchronicity; calculated from R-squared in a market model
GW	Greenwashing index; measured by the difference of a firm's ESG disclosure score and its ESG rating score from Huazheng

ESG	Corporate ESG performance; measured by ESG ratings published by Huazheng
LTIO	The long-term institutional ownership; measured by the ratio of the number of shares held by long term institutional investors to the total number of shares outstanding
ANACOV	Analysts' coverage; the log of the number of analysts following the company within a year
IR	Information disclosure rating; measured by information disclosure ratings published by the China Securities Regulatory Commission (CSRC)

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