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Shu Guo, ZhongXiang Zhang

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By **Shu Guo**, Ma Yinchu School of Economics, Tianjin University and China Academy of Energy, Environmental and Industrial Economics
ZhongXiang Zhang, Ma Yinchu School of Economics, Tianjin University and China Academy of Energy, Environmental and Industrial Economics

Summary

The green credit policy plays a vital role in promoting enterprise upgrading. Using a thirteen year panel data of listed companies in China (2007 2019), this study uses the difference in differences (DID) method to examine the effects of the Green Credit Guidelines in 2012 (*GCG2012*) on the firm level total factor productivity (TFP). Our results show that the *GCG2012* significantly increases the TFP of companies in green credit restricted industries. This finding remains robust through employing the PSM-DID model, alternating the treatment group, changing the sample period, and controlling the effects of other environmental policies and financial crises. This effect is more pronounced for private enterprises, companies with worse debt paying ability, companies in highly competitive industries and companies in regions with higher financial liberalization. The impact mechanism test indicates that increasing the green innovation and reducing the agency costs (including green agency costs and traditional agency costs) are two possible channels to boost firm level TFP. Further analysis shows that the *GCG2012* is effective not only for heavily polluting industries but also for light polluting industries, and that the *GCG2012* can improve the economic performance of firms in green credit restricted industries. Overall, this study reveals the micro mechanisms behind the long term impact of the *GCG2012* policy on firm level TFP, providing empirical evidence and policy suggestions for improving green credit policies and promoting green development.

Keywords: Green credit policy; green finance; total factor productivity; PSM-DID model; China
JEL Classification: Q48; Q53; Q55; Q58; O13; P28; R11; H23

Address for correspondence:
ZhongXiang Zhang
Founding Dean and Distinguished University Professor
Ma Yinchu School of Economics
Tianjin University
92 Weijin Road, Tianjin 300072, China
E-mail address: ZhangZX@tju.edu.cn

Green credit policy and total factor productivity: Evidence from Chinese listed companies

Shu Guo[a,b]; **ZhongXiang Zhang**[a,b,*]
[a] Ma Yinchu School of Economics, Tianjin University, Tianjin, China
[b] China Academy of Energy, Environmental and Industrial Economics, China

Abstract: The green credit policy plays a vital role in promoting enterprise upgrading. Using a thirteen-year panel data of listed companies in China (2007-2019), this study uses the difference-in-differences (DID) method to examine the effects of the Green Credit Guidelines in 2012 (*GCG2012*) on the firm-level total factor productivity (TFP). Our results show that the *GCG2012* significantly increases the TFP of companies in green credit restricted industries. This finding remains robust through employing the PSM-DID model, alternating the treatment group, changing the sample period, and controlling the effects of other environmental policies and financial crises. This effect is more pronounced for private enterprises, companies with worse debt-paying ability, companies in highly competitive industries and companies in regions with higher financial liberalization. The impact mechanism test indicates that increasing the green innovation and reducing the agency costs (including green agency costs and traditional agency costs) are two possible channels to boost firm-level TFP. Further analysis shows that the *GCG2012* is effective not only for heavily polluting industries but also for light polluting industries, and that the *GCG2012* can improve the economic performance of firms in green credit restricted industries. Overall, this study reveals the micro-mechanisms behind the long term impact of the *GCG2012* policy on firm-level TFP, providing empirical evidence and policy suggestions for improving green credit policies and promoting green development.

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[*] Corresponding author: ZhongXiang Zhang, Founding Dean and Distinguished University Professor, Ma Yinchu School of Economics, Tianjin University, 92 Weijin Road, Tianjin 300072, China. *E-mail address:* ZhangZX@tju.edu.cn.

1. Introduction

The environmental issues and the resulting consequences have attracted considerable attention and have been recognized across the globe (The World Bank, 2007; Aghion *et al*., 2016). Being the world's largest carbon emitter with emissions continuing to grow, China is facing daunting challenge to reduce pollution and achieve sustainable development while growing its economy (Zhang, 2000, 2017 and 2021). At the 75th UN General Assembly held in September 2020, China committed to capping its carbon emissions before 2030 and achieving carbon neutrality before 2060. Therefore, it is of great practical significance and urgency to promote green, circular, and low-carbon development (Zhang, 2021; Zhang *et al*., 2021b). To that end, China should use not only "end-of-pipe" treatment measures but also financial instruments, whose application in environmental governance has received increasing attention in recent years (Soundarrajan and Vivek, 2016) and helps to optimize resource allocation.

Financial instruments have the dual characteristics of financial resource allocation and environmental regulation, and are considered indispensable to achieve the goal of ecological environment governance. There are at least the three reasons. Firstly, the investment in environmental governance of the enterprise with limited funds must have a significant crowding-out effect on the productive investment in the short term (Duygan-Bump *et al*., 2015; Liu *et al*., 2021). Secondly, long-term financing constraints will inhibit business activity (Wen *et al*., 2021; Yao *et al*., 2021). Enterprises have to carry out technological innovation and green production to ease financing constraints (Wang and Wang, 2021; Yu *et al*., 2021). Lastly, financial instruments prod enterprises to upgrade and switch to the green economy (An *et al*., 2021). Thus, financial instruments as exemplified by green finance are an important measure to realize green development and promote high-quality economic development (Scholtens and Dam, 2007; Zhang and Wang, 2021). Thus, China has formulated a series of green finance policies, for example, the Green Credit Guidelines formulated by the China Banking Regulatory Commission in 2012 (CBRC, 2012), the Guidance on Building a Green Financial System issued by the People's Bank of China and seven other departments in 2016 (PBC *et al*., 2016), Pilot Zone for Green Finance Reform and Innovation set up by the State Council in 2017 (EMSC, 2017). And China becomes the first country to build a green financial system driven by the central government (Wang *et al*.,

2021). These green finance policies aim to constrain capital allocation in heavily polluting industries and direct resources away from backward highly polluting production capacity (An *et al*., 2021).

Total factor productivity fully measures the efficiency of industrial upgrading and the growth of total economic performance (Baier *et al*., 2006). Moreover, the Chinese economy relies on an extensive-growth mode with high investment, high energy consumption, and high pollution (Kadoshin, 2000). Promoting the total factor productivity is a vital way for China to realize higher quality, more efficient, and more sustainable economic development (Huang *et al*., 2019). Given that companies are the main participants in green development and key stakeholders in green finance, thus, it is of significantly academic and policy relevance to explore the impact of green finance on the firm-level total factor productivity.

Some studies have investigated the effects of the green finance policy on companies, and the results could be summarized as two different views (Evangelinos and Nikolaou, 2009; Wen *et al*., 2021; Zhang *et al*., 2021b). Some studies have found that the green finance policy has a significant inhibitory effect on polluting enterprises (Liu *et al*., 2017; Luo *et al*., 2017; Xu and Li, 2020). They suggest that the green finance policy would reduce the capital investment of energy-intensive enterprises (Liu *et al*., 2017; Wang *et al*., 2020) and firm performance in heavily polluting industries (Yao *et al*., 2021). Xu and Li (2020) discover that the green finance policy could reduce the debt financing maturity and increase the debt financing costs of high-pollution and high-emissions enterprises. By contrast, other studies have found that the green finance policy positively affects polluting enterprises (Zhang *et al*., 2011a; Wang and Wang, 2021). Wang and Wang (2021) show that the green credit restricted industries have better green innovation performance, and the agency costs of the green credit restricted industries have been significantly reduced, while investment efficiency has been considerably improved. Li *et al*. (2018) confirm that green loans can promote cleaner production theoretically. Unlike the end-of-pipe measures of traditional environmental policies, Sun *et al*. (2019) detect that the green finance policy forces firms to reduce pollution at source and imposes long-term credit constraints on polluters. To sum up, the current literature has discussed the impact of green finance policies on enterprises and has drawn different conclusions. There is still controversy on whether green finance policies can effectively promote the green development of polluting enterprises (Zhang *et al*., 2021b).

Moreover, few scholars have discussed the effect and mechanism of the green finance policy on the firm-level total factor productivity (Wen *et al*., 2021).

The green credit policy is one of the important green financial policies (Yao *et al*, 2021; Zhang *et al*., 2021b). Green credit is the most important component of green finance (He *et al*., 2019), as China's financial system is dominated by banks. The green credit balance has accounted for over 90% of all green financing balances (Wang and Wang, 2021). Therefore, the findings of green credit are representative. The China Banking Regulatory Commission (CBRC) formulated and issued the Green Credit Guidelines in 2012 (hereafter, *GCG2012*). The *CGC2012* has a directive function for the green credit of financial institutions, and is considered to be the first normative document about green credit in China (Liu *et al*., 2019; Wen *et al*., 2021). The *CGC2012* policy is a landmark that can help us better explore the effects of green credit. The policy effectiveness of the *CGC2012* policy depends on two aspects. First, the *CGC2012* policy is different from the traditional administrative means, and it is implemented by banks rather than local governments. As profit-making institutions, banks have greater flexibility in the implementation of the *CGC2012*. Meanwhile, although the *CGC2012* in China is a kind of economic means (Zhang *et al*, 2011a), it is not entirely regulated by the market mechanism. And banks do not receive economic incentives. Thus, banks may not fully implement the *CGC2012* policy without efficient financial incentives. In addition, as the government and the society have paid increasing attention to environmental issues, stricter environmental regulations may have negative effects on the production and operation of heavily polluting enterprises, thereby reducing their creditworthiness (Yao *et al*., 2021). Thus, banks may help companies promote economic transformation, and tap into the growth potential of the green economy (Aizawa and Yang, 2010). Second, the effectiveness of the *GCG2012* policy depends on how companies will react (Ding, 2019). It is worth noting that increasing the financing constraints of heavy polluters is not the ultimate goal. On the macro level, the *GCG2012* policy aims to achieve the transformation of the economy toward low-carbon and green growth by guiding resource allocation and eliminating highly polluting backward production capacity (He *et al*., 2019). And on the micro level, the real purpose of the *GCG2012* policy is to promote the green development of polluting enterprises, rather than inhibiting their upgrading. The *GCG2012* policy aims to push polluting enterprises away from projects that cause heavily environmental pollution (Zhang *et al*, 2011a), and reduce

their negative externalities. Faced with the financing constraints imposed by the *GCG2012* policy, whether polluters will choose to proactively improve their total factor productivity is subject to specific empirical verification.

Hence this paper aims to investigate the implementation effect of the *GCG2012* from an enterprise's microcosmic perspective. We use a DID estimation to explore the long-term relationship between the *GCG2012* and the total factor productivity of listed companies in green credit restricted industries from 2007 to 2019. We find that the *GCG2012* significantly increases the firm-level total factor productivity of the treatment group compared to the control group, which remains valid in a series of robustness tests. The analysis of the heterogeneity effects of the *GCG2012* illustrates that the *GCG2012* has positive effects on companies with worse debt-paying ability and companies in highly competitive industries. Moreover, the *GCG2012* can all increase the total factor productivity of private enterprises, state-owned enterprises and the companies in regions with different financial liberalization, but it has a greater influence on private enterprises and the companies in regions with higher financial liberalization. Furthermore, we discover that the *GCG2012* prods companies in green credit restricted industries to transform and upgrade by improving green technological innovation and reducing the agency costs, which include both traditional agency costs and green agency costs. Interestingly, the *GCG2012* could not promote non-green technological innovation and increase R&D expenditure in the treatment group. Most importantly, the further study shows that the *GCG2012* can promote the economic performance of companies by enhancing their total factor productivity, indicating that the *GCG2012* policy achieves a win-win for both the environment and the economy.

This paper contributes to the existing literature on the topic of green finance and the firm-level total factor productivity in three aspects. First, we investigate the impact of the green credit policy on the firm-level total factor productivity in green credit restricted industries, which more accurately evaluates the long-term effectiveness of the green credit policy. We find that the green credit policy generates the Porter effect in China, which complements with existing literature (Zhang *et al*, 2011a; Wang and Wang, 2021; Yao *et al*., 2021; Zhang *et al*, 2021a). Second, this study enriches the relevant literature on the micro-economic effects of the green credit policy by providing new evidence from China (Liu *et al*., 2017; He *et al*., 2019; Wen *et al*., 2021; Zhang *et al*., 2021b), the world's second-largest economy that is now contending with economic

transformations. The green credit policy not only prods companies in green credit restricted industries to enhance their total factor productivity by promoting green technological innovation and reducing their agency costs, but also increases the economic performance of firms. This study might provide empirical evidence and policy suggestions for improving green credit policies and promoting the green development of polluting enterprises. Third, this paper contributes to the research studying the firm-level total factor productivity. How to boost total factor productivity has been the concern of many countries across the globe. Our study identifies an important channel to enhance the total factor productivity of firms, that is, green finance can promote enterprise upgrading, which complements with the previous literature (Miao and Wang, 2012; Van Beveren, 2012; Ren *et al*., 2019; Herzer, 2022).

The remainder of the paper is organized as follows. Section 2 presents the hypothesis. Section 3 describes the research design. Section 4 analyzes the empirical results. Section 5 and Section 6 examine the effects of changing industry definition criteria and economic efficiency of the *GCG2012*, respectively. The conclusions and implications are described in Section 7.

2. Literature review and hypothesis development

2.1. The Green Credit Guidelines in 2012 and total factor productivity

On the macro level, the total factor productivity could promote high-quality economic development (Baier *et al*., 2006; Herzer, 2022). And on the micro level, firm-level total factor productivity can improve their competitiveness, which helps promote green transformation (Ren *et al*., 2019).

Few scholars have studied the effect of the green credit policy on the firm-level total factor productivity (Wen *et al*., 2021). Essentially, green finance is an extension and innovation of traditional environmental regulation. Many studies have investigated environmental regulation and corporate productivity (Viscusi, 1983; Porter and Van der Linde, 1995; Gray and Shadbegian, 2003; Becker, 2011; Rubashkina *et al*., 2015; Shapiro and Walker, 2018), and the findings are controversial and inconclusive. Firstly, environmental regulation has negatively effect on corporate productivity (Viscusi, 1983; Jorgenson and Wilcoxen, 1990; Gray and Shadbegian, 2003). Environmental regulation would increase the costs and delay investment decisions (Viscusi,

1983), which makes the enterprise uncompetitive in the same industry and puts a negative effect on the corporate productivity (Gray and Shadbegian, 2003). Barbera and McConnell (1990) find that command-and-control environmental regulation harms industry-level total factor productivity when studying the manufacturing industry in the U.S. Lanoie *et al*. (2008) prove that the extra cost caused by the strict environmental regulation can reduce total factor productivity. Secondly, some studies document that environmental regulation has positively effect on productivity (Porter and Van der Linde, 1995; Hamamoto, 2006; Rubashkina *et al*., 2015). Environmental regulation creates extra costs in the short term. However, in the long term, proper environmental regulations can increase the total factor productivity of companies by triggering innovation offsets (Porter and Van der Linde, 1995), and ultimately create superior earnings (Alpay *et al*., 2002). Testa *et al*. (2011) demonstrate that more flexible environmental regulations can significantly increase the research and development investment, thereby increasing firm productivity. Rubashkina *et al*. (2015) find that industry-level productivity growth is affected by environmental policies by using panel data from manufacturing sectors of 17 European countries. Lastly, some scholars believe that environmental regulation has no statistically significant effect on the total factor productivity, possibly because the gains from technical innovation offset the higher costs (Becker, 2011; Shapiro and Walker, 2018). Some hold that the relationship between environmental regulation and enterprise productivity depends on other factors, like the timing and strength of policy (Lanoie *et al*., 2008; Zhang *et al*., 2011b; Wang and Liu, 2014). It can be seen that the impact of environmental regulation on the firm-level total factor productivity is unclear. The *GCG2012* policy is an "initial-of-pipe" treatment measure and full lifecycle governance tool (Wang and Wang, 2021), which may be more effective to force enterprises to upgrade than the traditional environmental regulation.

Additionally, the *GCG2012* affects the firm-level total factor productivity in green credit restricted industries by allocating financial resources. The main reason for credit rationing is the information asymmetry between banks and enterprises, leading to adverse selection and moral hazards (Stiglitz and Weiss, 1981). Bank credit is still an important channel of financing for Chinese enterprises. However, due to the information asymmetry between banks and enterprises and the problems of financial restraint, the financial resource has been tilted towards state-owned enterprises and large enterprises. The imbalance in the allocation of financial resources has largely

pushed funds into polluting industries (Liu and Wen, 2019), which has resulted in companies in these industries having no incentive to improve their total factor productivity. However, after the *GCG2012* was enforced, companies in green credit restricted industries face more severe financial constraints (CBRC, 2012; Liu *et al*., 2017; He *et al*., 2019), leading them to increase total factor productivity to reduce costs and improve their competitiveness. The *GCG2012* policy affects the productivity of companies in green credit restricted industries by changing capital flow. Therefore, the hypothesis is provided.

H1. The *GCG2012* policy can significantly increase the firm-level total factor productivity in green credit restricted industries.

2.2. Mechanisms of the GCG2012 to promote total factor productivity

2.2.1 The GCG2012 promotes total factor productivity by enhancing green technological innovation

According to the Porter effect, formulating reasonable environmental policies has an "innovative compensation effect" on polluting firms (Porter and van der Linde, 1995), prompting their technological innovation, especially green innovation (Hamamoto, 2006; Lanoie *et al*., 2008). Differing from traditional environmental policy, the *GCG2012* mainly uses the financing channel to make enterprise environmental costs endogenous. Companies in green credit restricted industries have to pay the costs of the pollution that they emit, and they need to face worse credit availability and higher loan cost (Liu *et al*., 2017). Stricter financing constraints of companies in green credit restricted industries caused by the *GCG2012* would inhibit corporate technical innovation investment (Caggese and Cuñat, 2013). Innovation activities are featured by high investment, high degree of uncertainty, and long-period (Bansal and Hunter, 2003). Companies in green credit restricted industries don't have enough money to increase technological innovation investment. And they even may divert funds from technical innovation investment to rigidity expenditures such as maintaining production and operation (Liu *et al*., 2021), because technical innovation investment cannot bring benefits to offset the negative impact of the *GCG2012* on economic profit in the short term, but rigid expenditures can. Moreover, the *GCG2012* requires banks to supervise companies to protect the environment (Wang and Wang, 2021). Companies in green credit restricted industries have to invest more productive factors into emissions reduction

activities, which may have a crowding-out effect on technical innovation investment. Lu *et al*. (2021) find that green credit policies inhibit the technological innovation of heavy polluting enterprises, especially those with high external financing reliance.

Whether a company implements a technology innovation strategy depends on the level of incentives that it obtains (Borghesi *et al*., 2015). Faced with stricter environmental regulations, companies are more inclined to realize green innovation (Aghion *et al*., 2016). Green credit policies affect the enterprises' productivity by changing capital flow, which supports businesses to carry out cleaner production and encourages financial institutions to develop diversified green financial products. Green credit policies include a series of "initial-of-pipe" treatment measures and full lifecycle governance tools (Wang and Wang, 2021), which may be more effective to promote enterprises to green innovation than traditional environmental regulations. The *GCG2012*, one of the most representative green credit policies (Yao *et al*., 2021; Zhang *et al*., 2021b), has changed the incentive structure of enterprises for cleaner production and has promoted green technological innovation.

From the angle of enterprises, green innovation has gradually become an important driving force for green development (Chen, 2008), helping to promote high-quality economic development on the macro level. And green innovation has increasingly become an important driving force for enterprises to improve their market competitiveness, helping to accelerate energy conservation and emissions reduction and switch to the green economy. In the face of stricter green credit, only companies pursuing green innovation can mitigate the high environmental costs, as demonstrated by Goetz (2019) and He *et al*. (2019) using the enterprise data of America and China, respectively. From the angle of the *GCG2012*, it specifies that banks have to strengthen their support for green innovation of customers who are applying for a loan and cannot approve loans to customers who are not compliant with their environmental and social performance standards (CBRC, 2012). In addition, the implementation of the *GCG2012* has further clarified the direction of environmental regulation policies, which would help strengthen the determination of companies in green credit restricted industries to pursue green development.

Facing the dual challenges of the environmental policy and economic development, companies in green credit restricted industries do not have enough money to support technical innovation projects, but they must vigorously promote green innovation with limited technical

innovation investment, which may limit non-green technology innovation (Marin, 2014). Thus, the *GCG2012*, as an environmental policy, may has a crowding-out effect on enterprises' non-green innovation. The ultimate goal of a firm is to maximize its worth, and the *GCG2012* can influence their total factor productivity by pushing them to green innovation. Based on the above analysis, we propose the following hypothesis:

H2. Since the *GCG2012* was enforced, the technical innovation investment and non-green technological innovation have not increased, but green technological innovation has increased.

2.2.2 The GCG2012 promotes total factor productivity by reducing agency costs

According to the stakeholder theory, environmental policies can help to ease the conflict between managers and stakeholders and helps companies to better achieve a green transition (Kitsikopoulos *et al*., 2018). Stakeholder pressure can influence a firm's environmental strategy proposed by managers (Christmann, 2000). Companies need to gain the support of their stakeholders and satisfy their interests to achieve sustainable development (Sharma and Henriques, 2005). And managers should consider the interests of the stakeholders in the day-to-day management of the firms (Donaldson and Preston, 1995). Stakeholders have pressed firms to produce cleaner products (Henriques and Sadorsky, 1999), including government, social and environmental groups, suppliers, shareholders, employees, consumers, etc. Considering that the *GCG2012* influences the cash flow of companies in green credit restricted industries, it mainly harms the interests of shareholders. In this subsection, we focus on the relationship between shareholders and managers.

The *GCG2012* significantly increases the environmental costs of companies in green credit restricted industries, which may be even greater than the benefits of blind development (Xu and Li, 2020). Banks have lower costs in obtaining consumers' personal information and can effectively supervise corporate managers. Banks play a major role in supervising through differentiated lending rates that constrain the cash flow of enterprises (Diamond, 1984). Compared with traditional credit, green credit has stronger supervision (Wang and Wang, 2021). Green credit pays more attention to environmental protection. Distinguished from the profitability and security of traditional credit, green credit further requires banking institutions to investigate their customers' environmental and social risks. The *GCG2012* clearly states that banking institutions should take the environmental and social risks of their customers as one important basis for their credit rating,

credit management and risk control (CBRC, 2012). Moreover, environmental degradation is increasing and not easy to eliminate. Thus, the supervision of green credit is persistent and increasingly rigid. Managers have to work harder to seek opportunities for green development to ease credit constraints and enhance their total factor productivity to improve competitiveness and profits under the pressure of green credit supervision.

Following Wang and Wang (2021), we can distinguish the agency costs into traditional agency costs (*TAC*) and green agency costs (*GAC*). Green agency costs refer to the conflicting interests of environmental regulations between shareholders and managers, which can be understood as the costs caused by minimizing the agency problems of environmental penalties. Traditional agency costs have persisted since a company was established (Ang *et al*., 2000). Green agency costs come into being accompanied by environmental regulations, which present stage characteristics (Wang and Wang, 2021). Increasing environmental expenditure has positive effects on economic development and enterprise development at any stage (Zhang *et al*., 2019b). However, managers have more autonomy and artificial operation space in environmental expenditure because of the stage characteristics of green agency costs. Traditional agency costs have similarities to green agency costs, and thus managers also have more autonomy in management expenses.

Before the emergence of green credit, traditional environmental regulations usually adopt end-of-pipe treatment measures (Liu *et al*., 2021), leading to more environmental costs. Traditional environmental regulations could not influence the financing constraints of polluting enterprises, and not act as supervisors for their production processes. And the costs of traditional environmental regulations may be lower than the benefits of blind development. Managers may develop blindly for their own performance, which is not conducive to the stable advancement of the company, ultimately harming the interests of shareholders. Thus, shareholders need to pay more attention to environmental governance and bear more costs to monitor the environmental governance decisions of managers. After the emergence of green credit, it changes the capital flow and sets stricter credit requirements for companies in green credit restricted industries (Liu *et al*., 2017; He *et al*., 2019). And companies in green credit restricted industries are facing great pressures of reducing emissions and strict credit conditions. Banks act as supervisors for their

production processes. As a result, with the help of the bank's regulatory function, shareholders may spend fewer resources monitoring the environmental governance decisions of managers.

If a company with bountiful expenditures on the environment in green credit restricted industries fails to ease their financing constraints caused by green credit, it may cause dissatisfaction among major shareholders, small and medium-sized investors, and even the public (Wang and Wang, 2021). The *GCG2012* internalizes this dissatisfaction. This will increase the cost of managers' private benefits through environmental protection expenditure, thereby reducing green agency costs, and it will force managers to manage the business more diligently. Diligent managers and lower green agency costs can better contribute to the upgrading of the company, including total factor productivity. Therefore, the *GCG2012* can decrease green agency costs and enhance firm-level total factor productivity. In addition, the *GCG2012* could affect traditional agency costs, which have similarities with green agency costs. Thus, we propose the following hypothesis:

H3. Since the *GCG2012* was enforced, traditional agency costs have decreased, particularly green agency costs.

2.3. Economic efficiency of the GCG2012

The *GCG2012* can influence the cash flow of companies in green credit restricted industries by increasing credit availability (Liu *et al*., 2019), thereby reducing their polluting investment and increasing clean investment, which may eventually change their capital structure. Thus, the production and management of companies in green credit restricted industries may be greatly affected, that is, the *GCG2012* mainly optimizes resource allocation by changing the cash flow of enterprises. The *GCG2012* aims to promote the sustainable development of companies. According to the Porter effect, strict and flexible environmental policies not only prod companies to reduce their emissions, but also enhance their competitiveness and produce excess returns (Porter and van der Linde, 1995; Petitjean, 2019). Different from command-and-control regulations and market-based regulations, the *GCG2012* plays a significant role in environmental governance by optimizing capital allocation (Zhang *et al*., 2021a), indicating that it is more flexible.

On the one hand, the *GCG2012* mandates that banks should give priority to investing in companies that are undergoing a green transformation. Moreover, banks have an ability to monitor

the environmental responsibility of companies (Aintablian *et al*., 2007). Thus, companies in green credit restricted industries need to shift toward a green transformation and increase their TFP to reduce the financing constraints caused by the *GCG2012* policy. In this case, companies in green credit restricted industries that actively pursue green development opportunities can improve the expectations of institutional investors and get more capital support (Bajo *et al*., 2016). Institutional investors can help companies alleviate information asymmetries and provide more accurate analysis of markets and policies (Cornett *et al*., 2007), helping to improve their competitiveness and increase their earnings. Companies in green credit restricted industries need to increase green innovation investments and promote green production to meet the requirements of the *GCG2012* and reduce their credit constraints. As a result, their production process is more environmentally friendly, and the products are greener. Companies in green credit restricted industries send signals to the market that they actively transform to the green economy and assume social responsibility. A good social image attracts more customers (Hu *et al*., 2021), increasing product sales and ultimately boosting their profits.

The ultimate goal of enterprises is to maximize profits (Coibion *et al*., 2018). Enterprises improve their total factor productivity intending to reduce pollution and save costs, and ultimately improve competitiveness (Ren *et al*., 2019). The purpose of the *GCG2012* is to help companies in green credit restricted industries abandon the extensive-growth development and shift to sustainable development (He *et al*., 2019). At present, public awareness of environmental protection has been raised, and energy conservation and emissions reduction are the development trend. Given the developing trends, companies that actively promote low-carbon and green transformation can have better development prospects in the future. Wang and Wang (2021) prove that the *GCG2012* can significantly improve corporate economic performance, and Wu *et al*. (2021) point out that the total factor productivity of companies has a mediating effect on their economic performance. Therefore, we have reasons to propose the following hypothesis:

H4. Since the *GCG2012* was enforced, the total factor productivity of companies in green credit restricted industries can increase their economic performance.

3. Research design

3.1. Sample selection and data sources

To better explore the relationship between Guidelines and total factor productivity of enterprises, the sample companies in our study include Chinese A-share listed companies in heavy pollution industries from 2007 to 2019. Our study period without 2020 is to avoid the impact of the COVID-19 on enterprise development. The COVID-19 outbreak has led to the global economic downturn, which has negatively impacted the firm performance (Shen *et al*., 2020). Thus, the production and operation of listed companies have been inevitably affected by the COVID-19 outbreak since 2020. To mitigate this endogeneity, we decide to end the sample period in 2019. This study processes the sample as follows: (1) excluding listed companies in the financial and insurance industry; (2) excluding listed companies with asset-liability ratios less than 0 or greater than 1; (3) removing listed companies with more than two consecutive years of losses (including ST, ST* and PT); (4) removing listed companies with missing relevant data. The corporate innovation data in this paper comes from the Chinese Research Data Services Platform (CNRDS), and the main financial data is from the China Stock Market and Accounting Research database (CSMAR) and Wind database. After matching the above data, we get 20415 firm-year observations. We winsorize the main continuous variable at 1% to limit the outlier effects.

3.2. Variables selected

3.2.1. Total factor productivity (TFP)

There is controversy about what is the best method of estimating firm-level total factor productivity in the literature. Firm-level total factor productivity has been measured by a variety of methods, including non-parametric methods (Jefferson *et al*., 2008), semi-parametric methods (Olley and Pakes, 1996; Levinsohn and Petrin, 2003), and parametric methods (Blundell and Bond, 1998). Non-parametric methods have major shortcomings, not only does it not cover comprehensive information but also cannot solve the endogeneity problem. Although parametric methods can solve the endogeneity problem, they require samples with a sufficiently long period (Lu and Lian, 2012). Semi-parametric methods can effectively avoid the above problems. Therefore, this study follows the works of Wang and Lu (2019), Peng *et al*. (2021) and Wang *et al*.

(2021) and uses the models proposed by Olley and Pakes (1996, hereafter, OP) and Levinsohn and Petrin (2003, hereafter, LP) to measure firm-level TFP.

First, we use the LP model to measure firm-level TFP, and the function is as follows:

$$\ln Y_{it} = a_0 + a_k \ln K_{it} + a_l \ln L_{it} + a_m \ln M_{it} + \gamma_t + \delta_i + \varepsilon_{it} \quad (1)$$

Second, we use the OP model to measure firm-level TFP, and the function is as follows:

$$\ln Y_{it} = b_0 + b_k \ln K_{it} + b_l \ln L_{it} + b_i \ln I_{it} + b_a Age_{it} + b_s SOE_{it} + \gamma_t + \mu_j + \eta_k + \varepsilon_{it} \quad (2)$$

Among them, Y_{it} represents the enterprise output, which is measured by operating income; K_{it} represents the capital input, which is measured by net fixed assets; L_{it} represents the labor input, which is measured by cash payments to and on behalf of employees; M_{it} represents the intermediate input, which is measured by cash paid for goods and services; I_{it} represents the investment, which is measured by the cash paid for fixed assets, intangible assets and other long-term assets[1]. Age_{it} is the age of the firm, and SOE_{it} is a dummy variable that equals one if the i_{th} firm is a state-owned company. γ_t, δ_i, μ_j and η_k are the year, firm, city, and industry fixed effects, respectively. ε_{it} is the error term. Notably, whether a firm exits the market is considered in the OP model. The data on listed companies used in this paper have almost no exit problem. Thus, we build a dummy variable ($Exit$) that equals 1 if a firm belongs to ST or PT firms or if it was delisted or its industry code is changed, and 0 otherwise.

3.2.2. The Green Credit Guidelines in 2012

The Green Credit Guidelines in 2012 (*GCG2012*) requires the bank not to finance projects which may waste resources and pollute the environment, leading to financing constraints for polluting firms. On the macro level, the *GCG2012* policy helps guide the flow of funds from polluting investment to green investment. And on the micro level, the *GCG2012* policy not only helps financial institutions to strengthen oversight of fund users but also improves their own environmental social responsibility.

The implementation of the *GCG2012* makes the polluting firms face more severe regulation.

[1] We add one to Y, K, L, M, I and then take the natural logarithm.

The *GCG2012* policy aims to force companies in green credit restricted industries to upgrade to achieve green and sustainable development, rather than inhibit their development. Facing tighter financing constraints, companies in green credit restricted industries have to improve productivity to offset the negative impact of the *GCG2012* on their profit. Therefore, we can regard the *GCG2012* policy as a natural experiment to explore the influence of green credit on the total factor productivity of enterprises.

We conduct a DID to investigate the relationship between the *GCG2012* and the total factor productivity of enterprises. Following Wang and Wang (2021), we distinguish whether a firm belongs to the green credit restricted industry according to its four-digit International Standard Industrial Classification (hereafter, ISIC). According to the *GCG2012*, the China Banking Regulatory Commission has formulated classification standards for environmental and social risk in the *Key Evaluation Indicators for Green Credit Implementation* (CBRC, 2014). Specifically, nine industries are defined as Class A[2], including nuclear power generation, hydropower, water conservancy and river port construction, coal mining and processing industry, petroleum and gas extracting industry, ferrous metal mining and dressing industry, nonferrous metal mining and dressing industry, non-metallic mineral mining and dressing industry and other mining industries (CBRC, 2014). If the listed company belongs to these nine green credit restricted industries, $Treat_i$ equals one and we choose them as the treatment group; otherwise, $Treat_i$ equals zero and we choose them as the control group.

3.2.3. Control variables

Referring to existing literatures (Brandt *et al*., 2012; Wen *et al*., 2021; Demir *et al*., 2022), we introduce a series of control variables to eliminate interference of firm's economic characteristics that may affect TFP: (1) firm size (*Size*) is measured by the logarithm of employee; (2) firm performance (*ROA*) is measured by profit rate of assets; (3) firm age (*LnAge*) is measured by the logarithm of the year that a firm has survived; (4) state-owned enterprises (*SOE*), a dummy variable which equals one if a firm belongs to state-owned enterprises and zero otherwise; (5)

[2] The *Key Evaluation Indicators for Green Credit Implementation* (CBRC, 2014) classifies clients into different categories based on the environmental and social risks that they face. Class A refers to clients whose construction, production and operating activities take a toll on the environment that cannot be easily eliminated. Class B refers to clients whose construction, production and operating activities have negative environmental and social consequences but can be more easily eliminated through mitigation measures. Class C refers to clients whose construction, production and operating activities have no clearly adverse environmental and social consequences.

enterprise growth (*Growth*) is defined as revenue growth rate; (6) capital structure (*Lev*) is defined as debt asset ratio; (7) cash holdings (*Cash*) is measured by the sum of monetary funds and trading financial assets divided by total assets; (8) proportion of fixed assets (*Ppe*) is measured by fixed assets divided by total assets; (9) labor (*Labor*) is measured by total wage payments divided by total employment; (10) the proportion of institutional investors shareholding (*Inst*); (11) operating cash flow (*CFO*) is measured by cash flow from financing activities divided by total assets; (12) capital expenditure ratio (*Capital*) is measured by capital expenditure divided by operating cash flow.

The summary statistics of all variables used in the baseline regression are listed in Table 1. *Tfp_lp* is calculated by the LP model, whose mean value is 6.490, the standard deviation is 0.899, the minimum value is 4.496, and the maximum value is 8.847. This suggests that the total factor productivity of firms varies considerably over the sample period, as does *Tfp_op* calculated by the OP method. Moreover, other control variables differ significantly among the sample firms, providing the possibility for studying whether the green credit policy affects firm-level total factor productivity.

Table 1 Descriptive statistics.

Variable	Mean	Std. dev.	Min	Max
Tfp_lp	6.490	0.899	4.505	8.847
Tfp_op	3.344	0.713	1.861	5.327
Size	7.627	1.313	4.174	11.16
ROA	0.0437	0.057	-0.165	0.217
LnAge	2.078	0.829	0	3.219
SOE	0.423	0.494	0	1
Growth	0.441	1.367	-0.697	10.30
Lev	0.442	0.210	0.048	0.883
Cash	2.859	16.16	-67.71	94.16
Ppe	0.227	0.168	0.00231	0.720
Labor	11.32	0.628	9.856	13.29
Inst	46.87	23.62	0.493	90.79
CFO	0.044	0.074	-0.184	0.249
Capital	0.010	0.045	-0.091	0.321

3.3. Model specification

3.3.1. The effectiveness of GCG2012

Allen *et al*. (2005) take a skeptical attitude to China's market-oriented reform, and they

believe that the marketization mechanism is ineffective in China. The effective implementation of *GCG2012* is a prerequisite for studying the relationship between this policy and TFP. The *GCG2012* policy can affect firm-level TFP only if it has a real impact on the credit financing of heavy polluting enterprises (Liu *et al*., 2019), which is the basis of research in this study. Thus, we first examine whether the *GCG2012* is effective in reducing the long-term liabilities of the heavy polluting enterprise. We construct Equation 3 using a difference-in-differences methodology:

$$Debt_{ijt} = \alpha_0 + \alpha_1 Treat_i \times Post_t + \alpha_3 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (3)$$

where i represents enterprises, j represents 2-digit ISIC industries, and t represents years. $Debt_{ijt}$ is the logarithm of the long-term debt. $Treat_i$ is a dummy variable used to identify the green credit restricted industries, which equals 1 if a firm is in the treatment group, and 0 otherwise. $Post_t$ is the time dummy variable, which equals 1 for 2012-2019 and 0 for 2007-2011. α_1 captures the change in the long-term liabilities of the treatment group relative to the control group over the policy period. X_{it} represents a series of control variables, including firm size ($Size_{it}$), firm performance (ROA_{it}), firm age ($LnAge_{it}$), state-owned enterprises (SOE_{it}), enterprise growth ($Growth_{it}$), capital structure (Lev_{it}), cash holdings ($Cash_{it}$), proportion of fixed assets (Ppe_{it}), labor ($Labor_{it}$), the proportion of institutional investors shareholding ($Inst_{it}$), operating cash flow (CFO_{it}) and capital expenditure ratio ($Capital_{it}$). γ_t, δ_i and η_j are the year, firm and two-digit ISIC industry fixed effects, respectively. ε_{ijt} is the error term. Following Zhang *et al*. (2019b), we also choose cluster robust standard errors at the city level.

3.3.2. The impact of the GCG2012 on TFP

The difference-in-differences method is widely used, because it can efficiently tackle the problem of endogeneity in the regressions while effectively estimating policy effects (Wen and Zhao, 2021). To examine the relationship between the Green Credit Guidelines and firm-level total factor productivity, following Ren *et al*. (2019), this paper constructs a DID model:

$$TFP_{ijt} = \beta_0 + \beta_1 Treat_i \times Post_t + \beta_3 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (4)$$

where TFP_{ijt} is the logarithm of firm-level TFP that is *Tfp_lp* and *Tfp_op*. The meanings of

other variables are same as in Equation 3. We are most interested in the interaction term between $Treat_i$ and $Post_t$ ($Treat_i \times Post_t$), which examines the differential impact on the firm-level TFP in green credit restricted industries and non-green credit-restricted industries before and after the implementation of *GCG2012*. If β_1 is significantly bigger than 0, the *GCG2012* policy has dramatically increased the firm-level TFP in green credit restricted industries.

4. Empirical results and analysis

4.1. Test on policy effectiveness

The original purpose of the *GCG2012* is to force polluting enterprises to upgrade and switch to the green economy. If the *GCG2012* has not affected firm-level financing constraints in green credit restricted industries, it is pointless to explore its other effects. Thus, our first priority is to test whether the *GCG2012* policy can effectively reduce the firm-level long-term debt.

Columns (1) and (2) of Table 2 present the DID estimates of the impact of the *GCG2012* on firm-level debt corresponding to Equation 3. The coefficients of the interaction term ($Treat \times Post$) are significantly negative, indicating that the *GCG2012* is effective at improving financing constraints in green credit restricted industries. This result is consistent with the study of Yao *et al*. (2021) that shows the *GCG2012* policy can increase corporate financing constraints. After adding control variables, the coefficient of $Treat \times Post$ is significantly negative at the 1% level as shown in column (2), suggesting that compared to the control group, the firm-level debt in the treatment group declined by 49.03%[3]. Overall, the firms in green credit restricted industries face more regulatory pressure than those in the control group after the *GCG2012* policy.

The results of other control variables reported in Table 2 are as would be expected, which are consistent with Liu *et al*. (2019). We analyze the regression results of the control variables with firm, year and industry fixed effects. *Size*, *LnAge*, *Lev*, *Labor*, *Inst* and *Capital* can effectively improve *Debt*, and they usually shore up the solvency of a firm (Wen *et al*., 2021). *ROA*, *SOE*, *Growth*, *Cash* and *Ppe* have no effect on *Debt*, and *CFO* has a significant negative effect on *Debt*.

[3] Because the logarithm of *Debt* and *TFP* are used in our regression, we use $e^{\alpha/\beta}-1$ to calculate the policy effect.

4.2. Benchmark findings

This study estimates the impact of the *GCG2012* policy on firm-level TFP corresponding to Equation 4, and the results with firm, year and industry fixed effects are shown in column (3) to column (6) of Table 2.

The explained variable in columns (3) and (4) of Table 2 is *Tfp_lp* that calculated by the LP method. The regression results show that the coefficients of $Treat \times Post$, which we are most interested in, are positive and highly significant after controlling for the individual fixed effects, time fixed effects and industry fixed effects. After adding control variables, the coefficient of $Treat \times Post$ is significantly positive at the 1% level as shown in column (4), suggesting the firm-level TFP in the treatment group declined by 18.41% more than the control group after the *GCG2012* policy.

The explained variable in columns (5) and (6) of Table 2 is *Tfp_op* that calculated by the OP method. The regression results show that the coefficients of $Treat \times Post$ are positive and highly significant after controlling for the individual fixed effects, time fixed effects and industry fixed effects. After adding control variables, the coefficient of $Treat \times Post$ is significantly positive at the 1% level as shown in column (6), suggesting that the firm-level TFP in the treatment group declined by 26.36% more than the control group after the *GCG2012* policy.

In conclusion, no matter whether *TFP* is calculated by the OP model or the LP model, the *GCG2012* policy significantly increases the firm-level total factor productivity of the treatment group compared to the control group, demonstrating the robustness of the results and the validity of *Hypothesis* 1.

The underlying rationale is as follows. On the one hand, in theory, the *GCG2012* policy mainly uses the financing channel to make enterprise environmental costs endogenous, and raise the costs of debt financing in the short term. After the *GCG2012* is enforced, if the enterprise continues to maintain the original technology and production methods that emit a lot of pollution, it will face worse credit availability and higher loan cost (Liu *et al*., 2017; He *et al*., 2019). And it may even weaken its market competitiveness. Therefore, even without considering the need for clean technology, companies in green credit restricted industries need to intensify innovation and improve productivity to offset the negative impact of *GCG2012* on financial profit. Thus, in the

long term, the real purpose of the green credit policy is to promote the green development of companies in green credit restricted industries, rather than inhibiting their upgrading.

On the other hand, in terms of policy inspiration, the *GCG2012* policy designed by the China Banking Regulatory Commission is an extension and innovation of traditional environmental regulation. In contrast to the current environmental regulations, the green credit policy plays a significant role in environmental governance by optimizing capital allocation. It can increase green investment and reduce polluting investment, and ultimately achieve the goal of green development (Wen *et al*., 2021). Facing the dual challenges of environmental pollution and economic transformation, the *GCG2012* policy provides an important direction for the environmental policy in China.

The results of other control variables are as would be expected. We mainly analyze the regression results of the control variables with firm, year and industry fixed effects, as shown in column (4) and column (6) of Table 2. *ROA*, *Growth*, *Lev* and *CFO* are the important indicators for an enterprise's operation, and the results show that the better performance, the easier it is for a company to increase its total factor productivity. And Wen *et al*. (2021) come to a similar conclusion. *LnAge* has a positive effect on *TFP*, indicating that only companies with higher competitiveness are likely to survive longer and have higher productivity (Peng *et al*., 2021). Institutional investors can help companies to have a more accurate analysis of markets and policies, which is conducive to improving corporate governance（Cornett *et al*., 2007), as evidenced by the coefficient of *Inst* in this paper. Conversely, *Ppe* has a negative effect on *TFP*, probably because of the low liquidity of fixed assets, which is not conducive to enterprise upgrading. In addition, *SOE Cash* and *Capital* are not statistically significant.

Table 2 Mian results on the long-term debt and total factor productivity.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	*Debt*	*Debt*	*Tfp_lp*	*Tfp_lp*	*Tfp_op*	*Tfp_op*
Treat×*Post*	-0.395*	-0.399**	0.112**	0.210***	0.169***	0.234***
	(-1.84)	(-2.32)	(1.99)	(4.86)	(3.24)	(5.49)
Size		0.999***		0.276***		-0.048***
		(15.68)		(18.49)		(-3.20)
ROA		0.625		2.284***		2.231***
		(1.39)		(24.41)		(24.04)
LnAge		0.821***		0.040**		0.037**
		(10.91)		(2.16)		(2.13)

SOE		0.108		-0.024		-0.019
		(0.80)		(-0.56)		(-0.44)
Growth		0.013		0.012***		0.013***
		(0.90)		(2.62)		(2.96)
Lev		4.556***		0.695***		0.712***
		(21.39)		(15.32)		(15.43)
Cash		0.001		0.0002		0.0002
		(0.43)		(1.54)		(1.24)
Ppe		-0.191		-1.168***		-0.801***
		(-0.67)		(-16.92)		(-12.41)
Labor		0.942***		0.246***		-0.114***
		(14.72)		(10.85)		(-4.98)
Inst		0.009***		0.002***		0.002***
		(3.40)		(4.49)		(4.39)
CFO		-1.750***		0.381***		0.369***
		(-5.62)		(7.02)		(7.21)
Capital		0.767*		-0.159*		-0.106
		(1.75)		(-1.95)		(-1.29)
Constant	9.043***	-13.378***	6.496***	1.266***	3.349***	4.587***
	(2,168.67)	(-12.57)	(5,931.83)	(3.83)	(3,319.12)	(13.53)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	20,382	20,382	20,415	20,415	20,415	20,415
R-squared	0.736	0.783	0.871	0.912	0.834	0.863

Notes: This table shows the influences of the *GCG2012* of Debt and TFP. The dependent variables are the firm-level long-term debt (*Debt*) and total factor productivity measured by the LP model (*Tfp_lp*) and the OP model (*Tfp_op*), respectively. The interaction term (*Treat*×*Post*) is a dummy variable that equals one if a firm belongs to the green credit restricted industries in 2012 and beyond. All other variables are defined in Section 3.2.3. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.3. Robust analysis

4.3.1. Parallel trend assumption

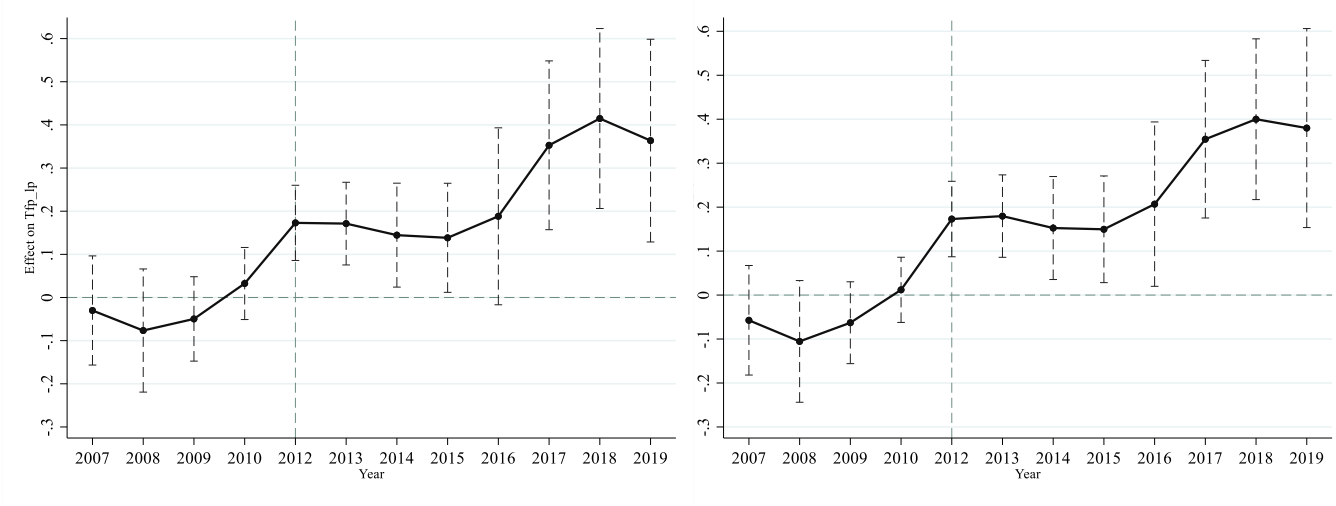
The DID estimates need to meet the identification assumption that the treatment group has the same trend line of change as the control group in the absence of policy intervention. The baseline regression results reflect the average treatment effect of the *GCG2012* policy on firm-level TFP, and do not capture the impact of the *GCG2012* policy over time. Therefore, this study uses the Event Study Approach proposed by Jacobson *et al*. (1993), to estimate the dynamic

effects of the *GCG2012* policy, and constructs the following model:

$$TFP_{ijt} = \theta_0 + \sum_{t=2007, t\neq 2011}^{2019} \theta_t \mathrm{T}reat_i \times Post_t + \theta_3 X + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (5)$$

where 2010, the year before the *GCG2012* policy implementation, is used as the base year and θ_t denotes a series of estimates from 2007-2019. The meanings of other variables are same as in Equation 4.

Fig.1 depicts the estimated results of *Tfp_lp* and *Tfp_op* at the 95% confidence intervals and finds that θ_t are not significant in 2007-2010, indicating that there is no obvious difference between the treatment and control groups before the implementation of the *GCG2012* policy, satisfying the parallel trend assumption. Moreover, we can find that after the implementation of the policy, θ_t becomes gradually larger from 2012 to 2019, suggesting that the effect of the *GCG2012* policy has become greater and greater over time. Therefore, the *GCG2012* policy has an increasing effect on promoting total factor productivity of companies in green credit restricted industries. Table A1 shows the specific coefficients of $Treat \times Post_t$, representing the dynamic effects of the *GCG2012* policy.



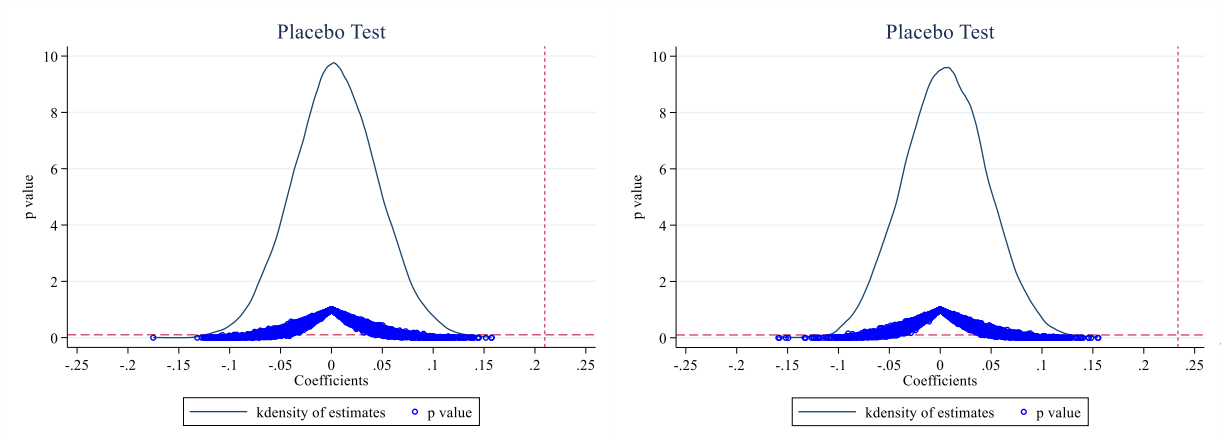
a. b.

Fig.1. The parallel trend test of the *GCG2012* policy and *TFP.* Notes: Fig. 1a and b report the results of *Tfp_lp* and *Tfp_op*, respectively. Figure presents the 95% confidence intervals and coefficients of θ_t which represents the interaction term between $Treat \times Post_t$ with firm, year and industry fixed effects. We select 2011 as the base year, so $Treat \times Post_{2011}$ is excluded. The dependent variables are the total factor productivity measured by the LP model (*Tfp_lp*) and the OP model (*Tfp_op*), respectively. Robust standard errors are clustered at the city-level level.

4.3.2. Placebo test

To further prove that the baseline results in this study are not by chance, we conduct a bootstrapping placebo test following Cai *et al*. (2016) by creating a placebo treatment. Specifically, the treatment group is randomly selected from our sample, and the others are regarded as the control group. Random sampling ensures that the independent variable ($Treat \times Post$) constructed in the placebo test has no effect on the total factor productivity of firms. In other words, any significant results in the placebo test would indicate that the baseline results in this paper are biased. We repeat the random sampling 500 times and 10000 times, and then perform the baseline regression on these pseudo-samples corresponding to Equation 4, as shown in Fig.A1 and Fig.2.

We can see that the coefficients of all $Treat \times Post$ in the pseudo-regressions are close to zero and are smaller than those in the true regression. Also, the true estimates in this paper (columns (4) and (6) of Table 2) are significant outliers in the placebo test. The distributions of the $Treat \times Post$ coefficients and their *p*-values are further plotted in Fig.A1 and Fig.2. The $Treat \times Post$ coefficients are close to zero point and most of their corresponding *p*-values are greater than 0.1 and insignificant. Therefore, the placebo test suggests that the baseline results in this paper are robust and not a case of chance.



a. b.

Fig.2. The placebo test of the *GCG2012* policy and *TFP* repeat 10000 times. Notes: Fig. 2a and b report the results of *Tfp_lp* and *Tfp_op*, respectively. The x-axis represents estimated coefficients. The curve represents the kernel density and the points represent p-values of 10000 estimates of *Treat*×*Post* randomly. The vertical line is the estimate of *TFP* in columns (4) and (6) of Table 2.

4.3.3. Propensity score matching (PSM) estimation

Considering the differences among our sample, we use Propensity Score Matching-Difference in Differences (PSM-DID) method to re-estimate Equation 4. The idea of the PSM method is to select a control group with the most similar characteristics to the treatment group (Rosenbaum and Rubin, 1983). Specifically, the logit model is used to match the new control group[4]. In this logit model, the dependent variable is $Treat_i$ which is a dummy variable, and independent variables are the control variables introduced in Section 3.2.3. In addition, the characteristics of the firms in the treatment group are not static. And not all the firms are consistently present during the sample period (2007-2019), as some were listed after 2007 and some were delisted before 2019. Thus, the treatment group is matched year by year to obtain another control group.

The PSM sample has highly similarity between the treatment and control groups, so we can consider that the difference in the firm-level total factor productivity between the treatment and control groups is mainly influenced by the *GCG2012* policy. Table 3 reports the results of the re-estimation of Equation 4 using the PSM sample. Columns (1) and (2) of Table 3 present the results of the PSM sample obtained by matching the sample without distinguishing the year. Columns (3) and (4) of Table 3 present the results of the PSM sample obtained by matching the sample year by year. All coefficients of $Treat \times Post$ are positive and significant, again demonstrating that the *GCG2012* can significantly increase firm-level total factor productivity in green credit restricted industries.

Table 3 PSM-DID results of the *GCG2012* policy and *TFP*.

	(1)	(2)	(3)	(4)
Dependent Variable:	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*
Treat×*Post*	0.237**	0.267***	0.186**	0.204***
	(2.50)	(3.08)	(2.28)	(2.78)
Constant	0.734	3.728**	-1.042	1.546
	(0.42)	(2.06)	(-0.62)	(0.91)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	14,557	14,557	15,153	15,153

[4] The k-nearest neighbor matching is used in this study where k is 2 and caliper size is 0.05.

R-squared	0.961	0.943	0.948	0.929

Notes: The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.3.4. Multiple fixed effect models

In the baseline regression, we control year fixed effects and firm fixed effects that can effectively control the influence of most unobserved factors. Although the listed firms we used in this study do not change provinces and industries easily, such small probability events still exist. Referring to Liu (2016), to further control the province-level and industry-level potential factors that change with time, this paper builds a multiple fixed-effect model. Columns (1) and (2) of Table 4 report the results of the multiple fixed-effect model including year fixed effects, province-year fixed effects and industry-year fixed effects. The reexamination results are significantly positive, indicating that our baseline results are robust.

4.3.5. Alternative indicator

In benchmark regression, we choose the firms in the green credit restricted industries as the treatment group according to the *Key Evaluation Indicators for Green Credit Implementation* (CBRC, 2014). But the treatment group used in benchmark regression contains only nine industries. Doing so can get more accurate results, but this policy is not enacted until two years after the *GCG2012*. Some financial institutions may still follow the standards set by other policies to define polluting industries. Thus, referring to Zhang *et al*. (2019a), we redefine polluting industries according to the *Guidelines for Industry Classification of Listed Companies*, including coal mining and processing industry, petroleum and gas extracting industry, etc (SEPA, 2010). If the listed company belongs to these 16 polluting industries, $Treat_i$ equals one and we choose them as the treatment group; otherwise, $Treat_i$ equals zero and we choose them as the control group.

Columns (3) and (4) of Table 4 report the results of an alternative measure of the polluting industries. The coefficients of $Treat \times Post$ are positive and statistically significant, no matter whether the explanatory variable is *Tfp_lp* or *Tfp_op*. The results indicate that the *GCG2012* policy can improve the TFP of polluting enterprises effectively, proving the robustness of our results.

4.3.6. Extend sample period

The sample period used in this study is from 2007 to 2019. The reason that we exclude 2020 is because the COVID-19 has severely impacted global economic development. To further verify the robustness of the results, we include firm-level data in 2020. The last two columns of Table 4 show the results of adding the 2020 sample. The significance and magnitude of the coefficients of $Treat \times Post$ are very close to those of the baseline regression.

Table 4 Robustness analyses: multiple fixed effects, alternative indicator and extend sample period

	(1)	(2)	(3)	(4)	(5)	(6)
	Multiple Fixed Effects		Alternative Indicator		Extend Sample Period	
Dependent Variable:	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*
Treat×*Post*	0.172**	0.184***	0.019*	0.048***	0.220***	0.245***
	(2.58)	(3.05)	(1.85)	(4.57)	(4.99)	(5.63)
Constant	1.333***	4.623***	-1.819***	0.405*	1.073***	4.436***
	(3.90)	(13.46)	(-8.46)	(1.86)	(3.53)	(14.24)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	YES	YES	YES	YES
Industry FE	NO	NO	YES	YES	YES	YES
Industry*Year FE	YES	YES	NO	NO	NO	NO
Province*Year FE	YES	YES	NO	NO	NO	NO
Observations	20,338	20,338	20,414	20,414	22,508	22,508
R-squared	0.921	0.877	0.919	0.868	0.908	0.858

Notes: Columns (1) and (2) report the results of controlling firm fixed effects with industry-year fixed effects and province-year fixed effects. Columns (3) and (4) report the results of alternative measure of the polluting industries. Columns (5) and (6) report the results of adding the 2020 sample. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.3.7. Exclude delisted companies and companies listed after 2012

Firstly, the listed company is not easily delisted, but such a situation does exist. A listed company will face worse credit availability and higher loan cost when it is at greater risk of delisting because the bank is keenly aware of its improper operation. Thus, firms on the verge of delisting face even worse credit availability. We cannot distinguish precisely whether their lower TFP are caused by the *GCG2012* or by their own operations. To address this endogeneity problem, we remove the delisted companies and re-estimate Equation 4. As shown in columns (1) and (2) of Table 4, the coefficients of $Treat \times Post$ are similar to the coefficients in baseline regression, suggesting that the implementation of the *GCG2012* policy does effectively force the treatment

group to improve their firm-level TFP, which is irrelevant to their own business.

Secondly, this study uses the DID method to test the relationship between the *GCG2012* and firm-level TFP. We need to analyze two changes: one is the change in firm-level TFP after the *GCG2012* policy was enforced, and the other is the change in firm-level TFP of green credit restricted industries compared to non−green credit restricted industries. Therefore, we focus on two factors at the same time, namely time (policy period) and industry (green credit restricted industry). However, some companies go public after 2012, whose data before 2012 is missing, leading to difficulty to analyze the impact of the *GCG2012* on them. That is, we can only observe the impact of the *GCG2012* policy on these companies after the policy was enacted and are unable to compare them with the pre-policy period, which may bias the results. Thus, we remove the companies listed after 2012 and re-estimate Equation 4. As shown in columns (3) and (4) of Table 4, the coefficients of $Treat \times Post$ are similar to the coefficients in baseline regression.

Lastly, we remove both the delisted companies and the companies listed after 2012 and re-estimate Equation 4. The results reported in the last two columns of Table 5 are consistent with the baseline regression, further demonstrating the reliability of our conclusions.

Table 5 Robustness analyses: exclude delisted companies and companies listed after 2012

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*
Treat×*Post*	0.209***	0.233***	0.201***	0.223***	0.201***	0.223***
	(4.86)	(5.49)	(4.52)	(5.08)	(4.52)	(5.08)
Constant	1.338***	4.641***	1.140***	4.485***	1.205***	4.533***
	(3.99)	(13.40)	(3.41)	(13.21)	(3.54)	(13.05)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	18,869	18,869	19,978	19,978	18,438	18,438
R-squared	0.909	0.857	0.914	0.865	0.912	0.859

Notes: Columns (1) and (2) report the results of dropping the delisted companies. Columns (3) and (4) report the results of dropping the companies listed after 2012. Columns (5) and (6) report the results of dropping both the delisted companies and the companies listed after 2012. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.3.8. The influence of the financial crisis

The financial crisis of 2008 severely affected the economic development of many countries,

leading to unusual volatility in financial markets. Financial institutions did not have enough resources to invest. The main effect of the financial crisis on our sample reflects in their financing needs and investment needs. First, following Durnev and Kim (2005), we measure potential external financing needs of companies to control for changes in their own financing needs by constructing *External*[5], which is a continuous variable. Secondly, referring to Ding and Knight (2011), we use *Salegrowth*, which is the annual rate of increase of main business revenue, to measure the investment needs of companies.

We introduce both *External* and *Salegrowth* as control variables in Equation 4 to control the effect of the financial crisis. The re-estimated results of Equation 4 are shown in columns (1) and (2) of Table 6. The coefficients of *External* are both significantly negative, indicating that firms with high financing needs face the cash crunch and thus they do not have more resources to improve the TFP. The coefficients of *Salegrowth* are both significantly positive, indicating that firms with high investment needs have enough capital to improve their TFP. And the coefficients of $Treat \times Post$, which we are most interested in, are positive and highly significant, suggesting that our conclusions are unrelated to the financial crisis.

Then, considering the events such as the financial crisis of 2008 and the Beijing Olympics that occurred during the sample period may have confounded the results of this study. And these events cannot be done in one day, they need time. Thus, we exclude observations from 2007 and 2008. As shown in the last two columns of Table 6, the conclusions are consistent with those in Table 2.

Table 6 Robustness analyses: the influence of the financial crisis

	(1)	(2)	(3)	(4)
Dependent Variable:	*Tfp_lp*	*Tfp_op*	*Tfp_lp*	*Tfp_op*
Treat×*Post*	0.193***	0.217***	0.192***	0.210***
	(4.28)	(4.93)	(4.03)	(4.68)
External	-0.081***	-0.057**		
	(-3.31)	(-2.00)		
Salegrowth	0.073***	0.077***		
	(4.87)	(5.29)		
Constant	1.470***	4.778***	1.170***	4.571***
	(4.31)	(13.50)	(3.34)	(12.79)
Controls	YES	YES	YES	YES

[5] $External = (Asset_t - Asset_{t-1})/Asset_{t-1} - ROE_t/(1 - ROE_t)$, where $Asset$ represents the total assets of the enterprise, and ROE represents the return on equity of the enterprise.

Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	19,823	19,823	17,907	17,907
R-squared	0.917	0.872	0.923	0.880

Notes: Columns (1) and (2) report the results of adding *external* and *salegrowth*. Columns (3) and (4) report the results of dropping both the 2007 and 2008 sample. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.4. Difference-in-difference-in-differences (DDD)

One issue in the DID model we proposed is that other environmental policies may also affect the firm-level TFP of the treatment and control group in addition to the *GCG2012* policy, which may bias the estimates. Therefore, to distinguish the *GCG2012* policy effects from other environmental policy effects in the same period is one of the key and difficult points of this study. Compared with other traditional environmental policies in the same period, the characteristic of the *GCG2012* is that it mainly uses the financing channel to make enterprise environmental costs endogenous. Following Lu *et al*. (2021), we further construct the DDD model by adding the corporate credit constraints to Equation 4 to mitigate the effect of other environmental policies on causal connections.

Theoretically, polluting firms that are more dependent on external financing are relatively more affected by the *GCG2012*, while other traditional environmental policies do not have an immediate impact on credit availability. That is, if the change in the firm-level TFP of our sample is entirely influenced by other traditional environmental policies but not by the *GCG2012*, the *GCG2012* cannot have significant heterogeneity effects on the TFP of companies in green credit restricted industries with different external financing reliance. Specifically, we use "net accounts receivable/total assets" to measure corporate credit constraints, namely *Cre*. The firm with higher *Cre* is easier to rely on external financing and more susceptible to the *GCG2012*. We employ a dummy variable to classify corporate credit constraints, namely *Credit*. To further excavate the causal relationship between the Green Credit Guidelines and firm-level total factor productivity, this study constructs a DDD model:

$$\begin{aligned} TFP_{ijt} = {} & \varphi_0 + \varphi_1 Treat_i \times Post_t \times Credit_i + \varphi_2 Treat_i \times Post_t + \varphi_3 Treat_i \times Credit_t \\ & + \varphi_4 Post_t \times Credit_i + \varphi_5 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \end{aligned} \tag{6}$$

where, *Credit* is a dummy variable, and if Cre_{ij} is higher than the median of the j_{th} industry in our sample by year, $Credit_i$ equals 1; otherwise, $Credit_i$ equals zero[6]. The meanings of other variables are same as in Equation 4. We are most interested in the coefficients of the interaction term ($Treat_i \times Post_t \times Credit_i$), which test the causal relationship between the firm-level TFP and the *GCG2012*. If φ_1 is significantly bigger than 0, the *GCG2012* policy can better boost the TFP of firms with stricter commercial credit constraints in green credit restricted industries. Table 7 reports the average treatment effects of the DDD model corresponding to Equation 6, which are generally consistent with those of the DID model corresponding to Equation 4. Thus, the results of this paper empirically demonstrate that the GCG2012 policy has contributed to boosting the firm-level TFP.

Table 7 The results of DDD method

	(1)	(2)
Dependent Variable:	*Tfp_lp*	*Tfp_op*
Treat×*Post*×*Credit*	0.173**	0.153**
	(2.24)	(2.06)
Treat×*Post*	0.111	0.146**
	(1.53)	(2.13)
Treat×*Credit*	-0.116*	-0.084
	(-1.68)	(-1.26)
Post×*Credit*	-0.076***	-0.070***
	(-6.83)	(-6.24)
Constant	1.387***	4.668***
	(4.26)	(14.03)
Controls	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	20,402	20,402
R-squared	0.913	0.864

Notes: This table shows the results excluding the effects of other environmental policies. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

[6] $Credit_i$ equals 1, indicating that the i_{th} firm faces stricter commercial credit constraints and higher reliance on external financing; and $Credit_i$ equals 0, indicating that the i_{th} firm faces more ease commercial credit constraints and lower reliance on external financing.

4.5. Heterogeneity analysis

The effects of the *GCG2012* policy may be affected by the enterprises' own specific situation, the industry environment and the macroscopic environment factors. Thus, this subsection explores the heterogeneity effects of the *GCG2012* on firm-level TFP by ownership, debt-paying ability, industrial competition degree and province financial marketization.

4.5.1 Heterogeneity tests based on firm-level characteristics

Firstly, we test the heterogeneity effect of the *GCG2012* on state-owned enterprises (hereafter, SOEs) and private enterprises (hereafter, non-SOEs). In recent years, the differences between SOEs and non-SOEs have caused considerable controversy. Some scholars point out that only privatization reforms can solve the efficiency problems of SOEs (Jefferson and Su, 2006). Other scholars argue that the privatization reform of SOEs cannot solve the existing problems and may even lead to the loss of state assets (Lin *et al*., 1998). Our results imply that the *GCG2012* policy can effetely boost the firm-level TFP. Nonetheless, it is necessary to note that the *GCG2012* policy is an act that the government indirectly intervenes in the market, essentially. Thus, is the *GCG2012* more likely to improve the TFP of SOEs or non-SOEs?

The *GCG2012* may have different impacts on the TFP of SOEs and non-SOEs because they are significant differences in political connection, business objective, the external environment, interior corporate governance, and so on. In political connection, SOEs correlate more closely to the government than non-SOEs (Wang and Lu, 2019). SOEs can get more information about policies, thereby making changes in time. In business objective, non-SOEs are more focused on pursuing financial benefits, while SOEs are more focused on social responsibility (Lin *et al*., 2004). Thus, SOEs may take on more tasks to reduce emissions. The environmental policies may achieve their goals by sacrificing SOEs' interests. In the external environment, SOEs face a better external management environment, including greater credit availability and more policy trend (Allen *et al*., 2005), and thus have less incentive to increase their TFP. In interior corporate governance, SOEs are easily controlled by managers, having a weaker level of corporate governance, thereby leading to slower TFP growth.

Columns (1) and (3) of panel A in Table 8 report the effect of the *GCG2012* on the SOEs' *TFP*, and the coefficients of $Treat \times Post$ are significantly positive at the 1% level. Columns (2)

and (4) of panel A in Table 8 report the effect of the *GCG2012* on the non-SOEs' *TFP*, and the coefficients of $Treat \times Post$ are significantly positive at the 10% level. These results show that the *GCG2012* policy can both boost the TFP of SOEs and non-SOEs. Further comparing the value of the coefficients of $Treat \times Post$ for SOEs and non-SOEs, we find that the *GCG2012* has a greater influence on non-SOEs. These also suggest that the *GCG2012* is stricter for non-SOEs, thereby prodding them to improve their TFP.

Secondly, we test the heterogeneity effect of the *GCG2012* on firm-level TFP by debt-paying ability. Debt-paying ability refers to a company's ability to repay its debts, that is, its ability to repay its debts with earnings from operating activities. The debt-paying ability directly affects whether the enterprise can repay the principal and interest of the loan on time. The better the debt-paying ability of an enterprise is, the easier it is to obtain funding. On the one hand, banks tend to provide more loans or renew loans to companies with better debt-paying ability. On the other hand, other financial institutions are more willing to invest in companies with better debt-paying ability. In general, companies with better debt-paying ability are more preferred among financial institutions and investors, and have weaker financing constraints. Thus, the *GCG2012* puts less regulatory pressure on companies with better debt-paying ability than others, because they have easier credit availability and richer financing channels.

We use liquidity rate which is current assets divided by current liabilities to measure the debt-paying ability. Specifically, the sample is further subdivided into two subsamples according to the median of liquidity rate by year. Then, we re-estimate Equation 4 and the results are shown in panel B in Table 8. We can find that the coefficients of $Treat \times Post$ in the better debt-paying ability subsample are positive and insignificant, and the coefficients of $Treat \times Post$ in the worse debt-paying ability subsample are significantly positive at the 1% level, indicating that the *GCG2012* only can increase the firm-level TFP in green credit restricted industries with worse debt-paying ability. The finding is in line with our analysis, that is, the *GCG2012* fail to prod companies in green credit restricted industries with better debt-paying ability in green credit restricted industries to improve their TFP. The result suggests the *GCG2012* does affect firm-level TFP by changing capital flows.

4.5.2 Heterogeneity tests based on industry-level characteristic

The *GCG2012* policy may also have significant heterogeneity effects on firm-level TFP in

industries with different degrees of competition. On the one hand, companies in highly competitive industries have greater abilities to gather and use information about the market and government, so they can adjust themselves to the new policy as soon as possible (Coibion *et al*., 2018). On the other hand, Melville *et al*. (2007) find that companies under high competitive pressure are more likely to increase innovation and productivity. Therefore, facing the dual policy and market test, companies in highly competitive industries may have more motivation to boost their TFP.

Specifically, we measure industry competition degree as the inverse of the standard deviation of main business profit margin for all sample companies of the same industry in the same year and classify the industries according to the two-digit ISIC industries (Nickell, 1996). Then, our sample is further subdivided into two subsamples according to the median of industry competition degree by year. Columns (1) and (3) of panel C in Table 8 report the effect of the *GCG2012* on the firm-level *TFP* in highly competitive industries, and the coefficients of $Treat \times Post$ are significantly positive at the 1% level. Columns (2) and (4) of panel C in Table 8 report the effect of the *GCG2012* on the firm-level *TFP* in less competitive industries, and the coefficients of $Treat \times Post$ are negative and insignificant. These results show that the *GCG2012* policy only boosts the firm-level TFP in highly competitive industries, but is ineffective in less competitive industries. This result is consistent with our analysis that heavy polluting enterprises in highly competitive industries have more incentive and pressure to improve TFP than companies in less competitive industries. Companies in less competitive industries rest on their laurels and then stagnate because of a lack of competition, resulting in the coefficients of $Treat \times Post$ are negative in columns (2) and (4).

4.5.3 Heterogeneity tests based on province-level characteristic

Financial liberalization is defined as a shift in the operation of financial sectors and the allocation of financial resources from being primarily regulated by the government to being primarily determined by the market. Financial liberalization has significant effects on corporate performance and economic welfare, and has been the main aim of financial reform in developing countries since the 1970s. The financial system structure largely determines the financing channels of firms, which in turn influences the effect of policies on the entity enterprises (Ma and Lin, 2016). The financial system becomes more and more consummate and widens the channel for

investment and financing in China. Heavy polluting enterprises in regions with high financial liberalization may be better affected by the *GCG2012*. The reason is that the higher the financial liberalization, the richer the financing channels, thus easing the financing constraints of heavy polluters. Since the implementation of the *GCG2012* policy, enterprises in green credit restricted industries have faced worse credit availability and higher loan cost, resulting in insufficient funds for innovation and even production. The improvement of financial liberalization can help alleviate this problem. Thus, the higher financial liberalization can help the *GCG2012* to prod companies in green credit restricted industries to boost their TFP more quickly.

We use the financial marketization index proposed by Wang *et al*. (2019) to measure financial liberalization. Specifically, the sample is further subdivided into two subsamples according to the tertiles of financial liberalization by year (FL_t). If the firm is in a province with financial liberalization greater than FL_t, we include it in the higher financial liberalization subsample; otherwise, we include it in the lower financial liberalization subsample. Columns (1) and (3) of panel D in Table 8 report the effect of the *GCG2012* on firm-level *TFP* of the higher financial liberalization subsample, and the coefficients of $Treat \times Post$ are significantly positive at the 1% level. Columns (2) and (4) of panel A in Table 8 report the effect of the *GCG2012* on firm-level *TFP* of the lower financial liberalization subsample, and the coefficients of $Treat \times Post$ are also significantly positive at the 1% level. These results show that the *GCG2012* policy can both boost the TFP of the two subsamples.

Further comparing the value of the coefficients of $Treat \times Post$ for the two subsamples, we find that the *GCG2012* has a greater influence on heavy polluting enterprises in the higher financial liberalization subsample, which is consistent with our analysis. The *GCG2012* has reduced the credit availability of companies in green credit restricted industries. Companies in green credit restricted industries with stricter financing constraints don't have enough fund to promote green development, leading to higher credit costs. It's a vicious circle. Thus, in the short term, the *GCG2012* may have negative effects on the TFP of heavy polluting enterprises (Wen *et al*., 2021). The higher financial liberalization can provide more funding for the upgrade of polluting enterprises to reach the required standard of the *GCG2012*, which can help solve this problem. In the long term, the *GCG2012* aims to prod companies in green credit restricted industries to shift toward a green economy, rather than inhibit their development. And the higher

financial liberalization can help the *GCG2012* policy do this.

Table 8 Heterogeneity analyses.

	(1)	(2)	(3)	(4)
Dependent Variable:	*Tfp_lp*		*Tfp_op*	
Panel A: Ownership	*SOEs*	*Non-SOEs*	*SOEs*	*Non-SOEs*
Treat×*Post*	0.163***	0.349*	0.193***	0.342*
	(3.53)	(1.76)	(4.13)	(1.70)
Constant	1.418**	1.364***	4.648***	4.746***
	(2.52)	(3.60)	(9.02)	(11.56)
Observations	8,765	11,573	8,765	11,573
R-squared	0.926	0.905	0.880	0.866
Empirical *p*-values	-0.185***		-0.149***	
Panel B: Debt-paying ability	*Better*	*Worse*	*Better*	*Worse*
Treat×*Post*	0.067	0.211***	0.082	0.232***
	(0.48)	(4.49)	(0.60)	(5.03)
Constant	1.690***	2.403***	5.119***	5.516***
	(3.65)	(4.63)	(10.85)	(10.69)
Observations	9,845	10,091	9,845	10,091
R-squared	0.868	0.917	0.853	0.885
Empirical *p*-values	-0.144***		-0.149***	
Panel C: Industrial competition degree	*Higher*	*Lower*	*Higher*	*Lower*
Treat×*Post*	0.289***	-0.109	0.311***	-0.077
	(6.29)	(-0.57)	(7.02)	(-0.40)
Constant	1.647***	0.982**	4.890***	4.353***
	(4.29)	(2.06)	(13.58)	(8.98)
Observations	10,075	9,433	10,075	9,433
R-squared	0.917	0.933	0.874	0.892
Empirical *p*-values	0.397***		0.389***	
Panel D: Financial marketization	*Higher*	*Lower*	*Higher*	*Lower*
Treat×*Post*	0.246***	0.161***	0.243***	0.197***
	(2.81)	(3.19)	(2.93)	(3.96)
Constant	1.094***	1.736***	4.334***	5.115***
	(2.77)	(3.58)	(10.31)	(11.68)
Observations	11,823	8,461	11,823	8,461
R-squared	0.917	0.916	0.878	0.858
Empirical *p*-values	0.085**		0.046**	
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Notes: This table shows the results of four heterogeneity analyses. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values. Empirical *p*-value represents the

difference in coefficients of TFP between the two groups and is obtained by bootstrap 1000 times.

4.6. Potential mechanisms

Thus far, our results show that the *GCG2012* policy can improve the firm-level TFP in the treatment group. Then what is the mechanism of its effect? As mentioned above, the *GCG2012* may influence the firm-level TFP through two potential channels. Firstly, the *GCG2012* puts great pressure to polluting enterprises' financing. Considering the long-term interests, companies in green credit restricted industries reconsider the allocation of capital. They have to intensify innovation to improve productivity, which can reduce the pressure on their credit. And to meet the requirements of the *GCG2012*, they also need to realize green technological innovation. Secondly, the *GCG2012* significantly increases the cost of environmental regulation for companies, which outweighs the benefits of the model of inefficient and blind development. Facing the high cost of the *GCG2012,* shareholders have a strong incentive to urge companies to increase the TFP to reduce costs. Moreover, the higher cost of environmental regulation would strengthen the monitoring function of the *GCG2012*, thus reducing agency costs. The credit monitoring function of green credit also prods managers to work harder for enterprise upgrading. Following Baron and Kenny (1986) and Wen *et al*. (2004), we use the mediating effect method to test these two mechanisms, and construct the following models:

$$TFP_{ijt} = \beta_0 + \beta_1 Treat_i \times Post_t + \beta_3 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (4)$$

$$Med_{ijt} = \lambda_0 + \lambda_1 Treat_i \times Post_t + \lambda_3 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (7)$$

$$TFP_{ijt} = \omega_0 + \omega_1 Treat_i \times Post_t + \omega_2 Med_{ijt} + \omega_3 X_{it} + \gamma_t + \delta_i + \eta_j + \varepsilon_{ijt} \quad (8)$$

where Med_{ijt} represents the intermediary variables, including technological innovation and agency costs. The meanings of other variables are same as in Equation 4. In this subsection, the first step of the mediating effect model is consistent with our baseline regression, so we only report the results corresponding to Equation 7 and Equation 8.

4.6.1. Technological innovation

Technological innovation is an important contributor to total factor productivity (Liu and Xin, 2019). And environmental regulation promotes innovation, which leads to productivity growth (Hamamoto, 2006). Intuitively, we expect that the *GCG2012* may enhance firm-level TFP through

technological innovation. We choose the logarithm of R&D expenditure (*LnRD*), non-green patent applications (*LnNGP*), and green patent applications (*LnGP*) to measure technical innovation investment, non-green technological innovation, and green technological innovation[7], respectively. As shown in panel A of Table 9, the coefficient of $Treat \times Post$ is negative and insignificant in column (1), while the coefficients of $Treat \times Post$ and *LnRD* are significantly positive in columns (2) and (3). It shows that technical innovation investment can enhance firm-level TFP, but the *GCG2012* cannot promote firm-level TFP in the treatment group by increasing technical innovation investment. In panel B of Table 9, the coefficient of $Treat \times Post$ is negative and insignificant in column (1) and the coefficients of *LnNGP* are negative and insignificant in columns (2) and (3), indicating that the total factor productivity growth is not caused by non-green technological innovation after the *GCG2012* policy implementation, which is consistent with Marin (2014). Panel C of Table 9 reports the results of the mediator effect of green technological innovation, and we can find that the coefficients of $Treat \times Post$ and *LnGP* are significantly positive, suggesting that green patent applications plays an intermediary role between the *GCG2012* and firm-level TFP in the treatment group. The results in this subsection support *Hypothesis* 2.

The *GCG2012* cannot exert an incentive effect on enterprises' innovation. The *GCG2012* cannot push companies in green credit restricted industries to increase R&D expenditure because the *GCG2012* may reduce their cash flow, which is the primary source of funding for innovation. And the *GCG2012* has a crowding-out effect on enterprises' non-green innovation. The purpose of the *GCG2012* is to promote the optimal allocation of financial resources between the environmental abatement and economic activities. Companies in green credit restricted industries need to reduce the input of polluting and low-efficiency sectors and increase the input of clean and high-efficiency sectors, which might help them improve productivity and get loans more easily. Therefore, in order to ease credit constraints, firms in the treatment group need to allocate more funds to green technology innovation under the condition of limited technical innovation investment. And they even may divert funds from non-green technological innovation to green

[7] Considering that the distribution of patent applications is right-skewed, we add one to the number of patent applications and then take the natural logarithm, including non-green patent applications (*LnNGP*) and green patent applications (*LnGP*).

technological innovation. The technical advance is the basis of the enterprise's development. Similarly, more green technological innovation can lead to higher firm-level TFP.

Table 9 The channel analyses through technological innovation.

	(1)	(2)	(3)
Dependent Variable:	*Med*	*Tfp_lp*	*Tfp_op*
Panel A: Technical innovation investment			
Treat×Post	-0.168	0.132**	0.159**
	(-0.87)	(2.03)	(2.51)
LnRD		0.037***	0.037***
		(6.98)	(6.86)
Constant	3.238***	0.550	4.220***
	(3.69)	(1.36)	(10.93)
Observations	13,977	13,977	13,977
R-squared	0.869	0.940	0.898
Panel B: Non-green technological innovation			
Treat×Post	0.116	0.209***	0.233***
	(1.60)	(4.86)	(5.49)
LnNGP		0.006	0.006
		(1.41)	(1.27)
Constant	-0.380*	1.272***	4.592***
	(-1.79)	(3.86)	(13.58)
Observations	20,415	20,415	20,415
R-squared	0.643	0.912	0.863
Panel C: Green technological innovation			
Treat×Post	0.071**	0.209***	0.233***
	(2.12)	(4.85)	(5.48)
LnGP		0.016**	0.014*
		(1.98)	(1.70)
Constant	-0.380*	1.272***	4.592***
	(-1.79)	(3.86)	(13.58)
Observations	20,415	20,415	20,415
R-squared	0.643	0.912	0.863
Controls	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Industry FE	YES	YES	YES

Notes: Med represents R&D expenditure (*LnRD*), non-green patent applications (*LnNGP*) and green patent applications (*LnGP*), respectively. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

4.6.2. Agency costs

The *GCG2012* can affect the credit constraints of companies in green credit restricted

industries, and banks act as supervisors for their production processes and financial position, resulting in lower agency costs (Wang and Wang, 2021). The agency costs are not conducive to enterprise development (Guan and Lansink, 2006), including productivity (Hossain and Govindasamy, 2005). The management fee rate embodies the costs caused by agent's behaviors, which are mainly caused by the overconsumption of managers, and we use the management fee rate to measure traditional agency costs (*TAC*)[8] (Ang *et al*., 2000). Following Zhang *et al*. (2019b), we manually collect the environmental expenditure included under "management expense" on a firm's annual report and corporate social responsibility report. We then aggregate all environmental expenditures as environmental management expenses to measure green agency costs (*GAC*)[9]. The *GCG2012* has increased the credit costs and financial constraints for companies in green credit restricted industries (Liu *et al*., 2017; He *et al*., 2019), thereby affecting their cash flow. Faced with insufficient cash flow, managers have to manage the business more diligently. Shareholders are easier to monitor the production and operation of enterprise activities with the assistance of the bank's supervision, which is not conducive for managers to pursue selfish interests, namely agency cost. This can effectively reduce the agency costs and the savings can be used to promote enterprise upgrading, for example by increasing TFP.

Table 10 reports the mediator effects of *TAC* and *GAC*, respectively. Panel A tests whether the *GCG2012* can boost firm-level TFP in the treatment group through traditional agency costs. The coefficient of $Treat \times Post$ is significantly negative at the 1% level in column (1), indicating that the *GCG2012* significantly reduces traditional agency costs of companies in green credit restricted industries. The coefficients of *TAC* are significantly negative at the 1% level in columns (2) and (3), suggesting that companies with less traditional agency costs in green credit restricted industries can better promote their TFP. Meanwhile, the coefficients of $Treat \times Post$ are significantly positive at the 1% level in columns (2) and (3), suggesting that traditional agency costs play an intermediary role between the *GCG2012* and firm-level TFP in the treatment group. Panel B tests whether the *GCG2012* can boost firm-level TFP in the treatment group through green agency costs. Similarly, the coefficient of $Treat \times Post$ is significantly negative in

[8] $TAC = management\ \ expense/gross\ \ revenue$

[9] $GAC = environmental\ \ management\ \ expense/gross\ \ revenue$. The sample is missing too much as only a handful of listed companies have voluntarily disclosed environmental management expenses, including the afforestation fee, the green fee, and so on.

column (1), while the coefficients of $Treat \times Post$ are significantly positive in columns (2) and (3), suggesting that the *GCG2012* can significantly reduce firm-level green agency costs and enhance firm-level TFP in the treatment group. And the coefficients of *GAC* are significantly negative in columns (2) and (3), illustrating that companies in the treatment group can improve their TFP by reducing the green agency costs. The regression results reported in panel B display that green agency costs also play an intermediary role between the *GCG2012* and firm-level TFP in the treatment group. And the results of panel A and panel B show that the *GCG2012* can better boost firm-level TFP in the treatment group by reducing the agency costs, including traditional agency costs and green agency costs, which support our *Hypothesis* 3.

Table 10 The channel analyses through agency costs.

	(1)	(2)	(3)
Dependent Variable:	*Med*	*Tfp_lp*	*Tfp_op*
Panel A: Traditional agency costs			
Treat×*Post*	-0.033***	0.195***	0.218***
	(-5.60)	(4.63)	(5.27)
TAC		-0.448***	-0.475***
		(-3.06)	(-3.05)
Constant	0.512***	1.496***	4.831***
	(4.84)	(4.73)	(15.13)
Observations	20,415	20,415	20,415
R-squared	0.448	0.917	0.872
Panel B: Green agency costs			
Treat×*Post*	-0.053*	0.307***	0.307***
	(-1.71)	(2.61)	(2.74)
GAC		-0.133***	-0.137***
		(-2.67)	(-2.66)
Constant	0.822	0.893	4.646***
	(1.38)	(1.20)	(6.69)
Observations	2,388	2,388	2,388
R-squared	0.641	0.945	0.911
Controls	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Industry FE	YES	YES	YES

Notes: Med represents traditional agency costs (*TAC*) and green agency costs (*GAC*), respectively. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

5. Expand industry definition criteria

The *Key Evaluation Indicators for Green Credit Implementation* classifies clients into different categories based on their environmental and social risks (CBRC, 2014). Class A refers to clients whose construction, production and operating activities take a toll on the environment that cannot be easily eliminated. Class B refers to clients whose construction, production and operating activities have negative effects on the environment and society but can be easily eliminated through mitigation measures. In the previous section, this study demonstrates that the *GCG2012* can promote the total factor productivity of clients in Class A. Although the negative consequences caused by clients in Class B can be more easily eliminated through mitigation measures than those caused by clients in Class A, clients in Class B with inadequate mitigation measures to eliminate environmental and social risks are still listed as green credit restricted. Specifically, 25 industries are defined as Class B, including the pharmaceutical industry, thermal power generation industry, leather tanning industry, pulp manufacturing industry, and so on.

Thus, we redefine the criteria for green credit restricted industries, including both Class A and Class B, which is a total of 34 industries. Specifically, if the listed company belongs to these 34 green credit restricted industries, $Treat_i$ equals one and we choose them as the treatment group; otherwise, $Treat_i$ equals zero and we choose them as the control group. Then, we re-estimate Equation 4 and the results are reported in Table 11. Column (1) of Table 11 provides the result of the *GCG2012* and *Tfp_lp*, and Column (2) of Table 11 describes the relationship between the *GCG2012* and *Tfp_op*. We can find that the coefficients of $Treat \times Post$ are significantly positive at the 1% level both in columns (1) and (2). Thus, we can conclude that the *GCG2012* has a noticeable effect not only on the green credit restricted industries in Class A (heavily polluting industries) but also on the green credit restricted industries in Class B (lightly polluting industries), which are in line with Wang and Wang (2021). Unlike traditional environmental policies, the *GCG2012* can more effectively promote the firm-level total factor productivity in the green credit restricted industries, and the result in this subsection further demonstrates the effectiveness of the *GCG2012* policy.

Table 11 The results of expanding the green credit restricted industries.

	(1)	(2)
Dependent Variable:	*Tfp_lp*	*Tfp_op*
Treat×Post	0.070***	0.072***
	(4.12)	(4.17)
Constant	1.270***	4.593***
	(3.88)	(13.67)
Controls	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	20,415	20,415
R-squared	0.912	0.863

Notes: This table shows the results of expanding the green credit restricted industries to include Class A and Class B. The interaction term (*Treat×Post*) is a dummy variable that equals one if a firm belongs to the green credit restriction industries in 2012 and beyond. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

6. Further study: economic efficiency of the *GCG2012*

This study demonstrates that the *GCG2012* can promote the total factor productivity of companies in green credit restricted industries by pushing them to increase green innovation and reduce agency costs. Liu *et al*. (2014) indicate that economic incentive instruments can significantly increase the economic performance of firms. So does the *GCG2012* affect firm-level economic performance by boosting total factor productivity? We further test the economic efficiency of the *GCG2012* through TFP using the mediating effect method, and construct the following models:

$$ROS_{ijt} = \phi_0 + \phi_1 Treat_i \times Post_t + \phi_3 X_{it} + \gamma_t + \delta_i + \varepsilon_{ijt} \quad (9)$$

$$ROS_{ijt} = \mu_0 + \mu_1 Treat_i \times Post_t + \mu_2 TFP_{ijt} + \mu_3 X_{it} + \gamma_t + \delta_i + \varepsilon_{ijt} \quad (10)$$

where ROS_{ijt} represents the return on sales[10] and is used to measure the economic performance of the company. The meanings of other variables are the same as in Equation 4. In this subsection, Equation 9 tests whether the *GCG2012* can directly affect the economic performance of companies in green credit restricted industries, and Equation 10 tests whether the *GCG2012* can

[10] $ROS = operating\ profit/total\ sale$

affect their economic performance through total factor productivity.

Column (1) of Table 12 reports the regression results of Equation 9. We can find that the coefficient of $Treat \times Post$ is significantly positive at the 5% level, indicating that the *GCG2012* can improve the economic performance of companies in green credit restricted industries. And the coefficients of $Treat \times Post$ and *TFP* are also significantly positive in columns (2) and (3), showing that firm-level TFP plays an intermediary role between the *GCG2012* and the economic performance of companies in the treatment group. The regression results reported in Table 12 show that the *GCG2012* has achieved desirable results. In the long run, the *GCG2012* not only prods companies in green credit restricted industries to green development but also achieves a win-win for both the environment and the economy, as evidenced by Wang and Wang (2021). The conclusion is consistent with our previous analysis and *Hypothesis* 4 is tenable.

Table 12 Economic efficiency of the *GCG2012* through TFP.

	(1)	(2)	(3)
Dependent Variable:	*ROS*	*ROS*	*ROS*
Treat×*Post*	0.083**	0.072*	0.067*
	(2.12)	(1.82)	(1.67)
Tfp_lp		0.055*	
		(1.82)	
Tfp_op			0.072**
			(2.25)
Constant	-0.429	-0.498	-0.757*
	(-1.36)	(-1.50)	(-1.93)
Controls	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	20,416	20,416	20,416
R-squared	0.348	0.349	0.349

Notes: ROS represents the firm-level return on sales. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level; the numbers in parentheses are *t*-values.

7. Conclusions and implications

China's economy is undertaking the transition from high growth to high-quality development. Improving total factor productivity is the driving force to improve the quality of economic development and maintain high economic growth. To help realize green, low-carbon and high-

quality development, the Chinese government introduces green finance to incentivize and attract resources to tilt towards low-carbon green projects aimed at achieving the dual carbon goals. Unlike traditional environmental regulation, green credit can play a role in environmental governance from the initial stages of the production process and act throughout the whole production process, because of its ability to allocate funds. So, is there a contradiction between strengthening environmental management and improving the quality of economic development? The answer is no. This study uses the difference-in-differences method to control potential endogeneity problems, and examines the impact of the Green Credit Guidelines in 2012 (*GCG2012*) on the firm-level total factor productivity. We first test the effectiveness of the *GCG2012* policy, that is, whether it has effects on firm-level liabilities in green credit restricted industries. We find that the *GCG2012* policy can reduce firm-level long-term debt in the treatment group. Our results then show that the *GCG2012* has a significant positive impact on the total factor productivity of listed companies in green credit restricted industries by employing DID model and DDD model. We employ the PSM-DID model, build a multiple fixed-effect model, replace the polluting industries, extend the sample period, exclude delisted companies and companies listed after 2012, and eliminate the effects of financial crises, and our conclusions remain robust. Mechanism tests show that the *GCGC2012* can boost the firm-level TFP in the treatment group by increasing their green technology innovation and reducing their agency costs, including traditional agency costs and green agency costs. And the GCG2012 has a crowding-out effect on enterprises' non-green innovation. In addition, the *GCG2012* policy can both boost the TFP of SOEs and non-SOEs, and has a greater influence on non-SOEs, implying that the *GCG2012* is stricter for non-SOEs. Companies in green credit restricted industries with worse debt-paying ability are more sensitive to the *GCG2012* policy. The *GCG2012* policy only prods companies in highly competitive industries to improve their TFP, but has no effect on companies in less competitive industries. And regions with higher financial liberalization are more sensitive to the *GCG2012* policy. Our further analyses suggest that the *GCG2012* can improve the economic performance of firms in green credit-constrained industries by increasing their total factor productivity and the *GCG2012* is effective not only for heavy polluting industries, but also for less polluting industries. Based on the above findings, we provide the following recommendations.

Firstly, in order to further promote high-quality economic development, banking institutions should adequately adjust the allocations of credit resources to alleviate the problem of environmental pollution in China. Our empirical results demonstrate that the *GCG2012* policy effectively promotes the firm-level TFP in green credit restricted industries and achieves a win-win situation for the economic and environmental performance. Green finance in China does achieve the long-term goal of advancing green development, which generates the Porter effect in the current system. Financial institutions should achieve synergetic development of the breadth and depth of the green financial system by accelerating innovation and boosting service efficiency of green financial instruments, such as green bonds, green insurance, green funds and so on. Then, the green credit policy can better prod companies in green credit restricted industries to upgrade and switch to the green economy through the multiplex development of the green financial system. In addition, banks should combine the specific characteristics of each industry to propose targeted green credit standards and risk management requirements. They also should provide specifically green credit products and services for each region with the different levels of financial liberalization.

Secondly, companies should strengthen corporate governance, especially green governance and promote green innovation to reduce credit constraints. Companies should fully mobilize stakeholders to monitor corporate environmental decisions and take full advantage of the bank's monitoring function. Shareholders should both prevent managers from overspending on environmental expenses for their own ends and urge managers to allocate research and development expenditures appropriately. Companies in green credit restricted industries can promote their total factor productivity by alleviating agency problems and enhancing green innovation to achieve sustainable development and reduce their own financing constraints.

Appendix A

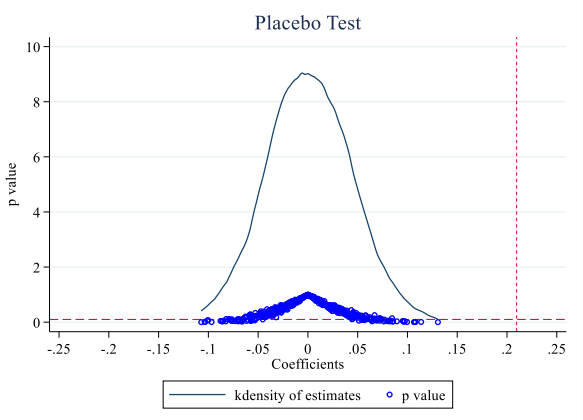
Table A1 Parallel trend assumption of the *GCG2012* policy and *TFP*.

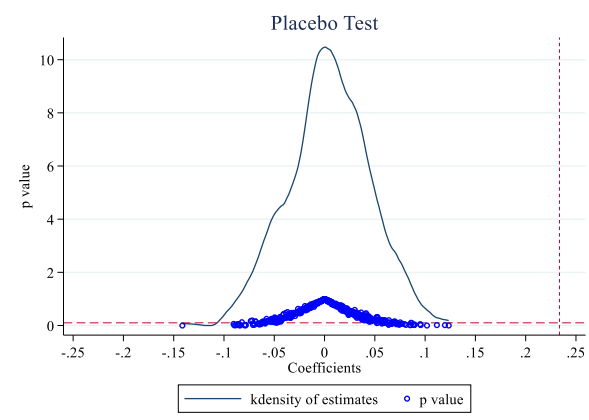
	(1)	(2)
Dependent Variable:	*Tfp_lp*	*Tfp_op*
$Treat \times Post_{2007}$	-0.030	-0.057
	(-0.47)	(-0.91)
$Treat \times Post_{2008}$	-0.077	-0.105

	(-1.06)	(-1.50)
Treat×*Post*$_{2009}$	-0.050	-0.063
	(-1.00)	(-1.33)
Treat×*Post*$_{2010}$	0.032	0.012
	(0.77)	(0.32)
Treat×*Post*$_{2012}$	0.173***	0.173***
	(3.91)	(3.97)
Treat×*Post*$_{2013}$	0.171***	0.180***
	(3.52)	(3.77)
Treat×*Post*$_{2014}$	0.145**	0.153**
	(2.36)	(2.56)
Treat×*Post*$_{2015}$	0.138**	0.150**
	(2.15)	(2.43)
Treat×*Post*$_{2016}$	0.188*	0.207**
	(1.81)	(2.18)
Treat×*Post*$_{2017}$	0.353***	0.355***
	(3.55)	(3.89)
Treat×*Post*$_{2018}$	0.415***	0.400***
	(3.92)	(4.31)
Treat×*Post*$_{2019}$	0.364***	0.380***
	(3.05)	(3.30)
Constant	1.255***	4.577***
	(3.80)	(13.52)
Controls	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	20,415	20,415
R-squared	0.912	0.863

Notes: This table addresses the parallel trend assumption of the *GCG2012* policy and *TFP* based on the event study approach. We select 2011 as the base year, so *Treat*×*Post*$_{2011}$ is excluded. The meanings of variables are the same as in Table 2. *, **, and *** represent the significance levels of 10%, 5%, and 1%, respectively; Robust standard errors are clustered at the city-level level. The numbers in parentheses are *t*-values.

Appendix B





a. b.

Fig.A1. The placebo test of the *GCG2012* policy and *TFP* repeat 500 times. Notes: Fig. A1a and b report the results of *Tfp_lp* and *Tfp_op*, respectively. The x-axis represents estimated coefficients. The curve represents the kernel density and the points represent p-values of 500 estimates of *Treat*×*Post* randomly. The vertical line is the estimate of *TFP* in columns (4) and (6) of Table 2.

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Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italia

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