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GREEN CREDIT POLICY, CORPORATE SOCIAL RESPONSIBILITY AND GREEN INNOVATION

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Abstract. Human activities have an increasingly serious impact on our natural surroundings. Hence, cutting-edge sustainable technologies are essential for both governmental agencies and the corporate sector as a pivotal means to safeguard the environment. This study aims to shed light on the function that corporate social responsibility (CSR) plays in enterprises by examining the relationship between green credit policy (GCP) and green innovation (GI). This research examines a total of 5,819 panels of Chinese listed businesses' data spanning from 2009 to 2021. The differences-in-differences (DID) model was used to assess hypotheses. The empirical results suggest that GCP has facilitated the adoption of GI by firms. GI in heavily polluting firms was elevated by 15% relative to the control group. The presence of CSR serves as a mediating and moderating factor in the relationship between GCP and the implementation of GI initiatives within firms. Lastly, based on the empirical results, relevant suggestions for optimizing GCP are proposed to achieve better environmental protection results.

Keywords: Keywords: green credit policy, corporate social responsibility, green innovation, differences-in-differences method, moderating effects, mediating effects.

JEL Classification: O31, O38, M38.

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1. Introduction

Environmental issues have always been an aspect of great concern to mankind in the process of development. Global warming has become more severe in recent years. The urgency of environmental protection has garnered global acceptance (Bai & Rub, 2024; Zhang et al., 2020a). The issuance of the Green Credit Guidelines by the China Bank Regulatory Commission (CBRC) in 2012 established the framework for China's GCP system. This initiative provided a solid platform for the development of green credit by all banks and financial institutions in China. The green credit guidelines apply to relevant financial institutions in China, such as commercial banks. GCP mainly includes the following three aspects: First, promoting credit funds to key areas such as the green economy, circular economy, and ecological economy and promoting the development of green industries. Second, strengthen environmental risk management and identify potential environmental risks for enterprises involved in credit disbursement. Finally, strengthen requirements for organizational management, information disclosure, and supervision (Du & Ullah, 2024; Zhang et al., 2021). The primary objective of the policy is to facilitate the advancement of green credit, enhance financial backing for en-

vironmentally friendly, low-carbon, and circular economic activities, mitigate environmental risks, optimize the credit composition, and foster the transition of China's growth paradigm (Fang et al., 2024; Wang et al., 2022). The execution of the green credit program has spanned almost a decade, warranting careful consideration and examination of its distinct impacts. An analysis of the several factors that affect the efficiency of GCP implementation and its consequences for companies might provide significant knowledge for the formulation and implementation of future environmental protection laws.

The existing body of research does not exhibit a consensus about the efficacy of green credit programs' implementation. The existing body of literature extensively examines the favorable impacts associated with green financing schemes. Green credit policies incentivize companies to develop low-carbon technologies and environmental protection technologies by imposing restrictions on loans provided to highly polluting companies (Liu et al., 2024; Chen et al., 2022; Liuyong & Zeye, 2022; Qin & Cao, 2022; Su et al., 2022; Sun et al., 2019; A. Zhang et al., 2022; K. Zhang et al., 2021). Nevertheless, it is worth noting that several academics contend that the economic and environmental consequences of GCP remain unknown (Wen et al., 2021; Wu et al., 2022). Wen et al. (2021) pointed out that GCP severely inhibits firms' external financing, leading to a decline in total factor productivity as firms suffer in research and development (R&D) investment and upgrading (Wen et al., 2021). Due to restrictions on the size and sources of financing, GCP can lead companies to adopt greenwashing, or GI, in order to obtain funding (He et al., 2022).

From the existing research on GCP, most studies focus on the external environment of enterprises as the starting point, studying the impact of environmental policies on enterprise innovation. However, few researchers integrate the internal factors of enterprises from an internal perspective and examine the policy effects under the comprehensive influence of internal and external factors. Hence, this work seeks to fill this research gap by conducting a complete analysis of firms' GI behavior, considering both their external legislative environment and internal CSR.

The research used the DID model technique to assess hypotheses. DID is able to determine the extent of an event's or policy's influence. The fundamental idea behind the approach is to divide the sample into two distinct groups: the treatment group, which is subject to the policy, and the control group, which is not. Using the data on the treatment and control groups before and after the policy was implemented, it is feasible to determine the magnitude of change in an indicator for both the treatment group and the control group. This allows for a comparison of the changes in the same indicator before and after the policy was implemented. The difference between the two changes is then calculated (the so-called "double difference"). The DID methodology is suitable for the assessment of the policy effects of GCP, and some studies have previously used the DID methodology to conduct related research (Li et al., 2024; Peng et al., 2022; Hu et al., 2021; Zhang et al., 2022; Qin and Cao, 2022; Chen et al., 2022).

This study makes significant contributions in the following areas: The objective of this study is to analyze the influence of GCP on the decision-making of firms regarding their GI. Initially, we quantitatively analyze the influence of GCP on the level of GI exhibited by firms. Next, we examine the mediating and moderating effects of CSR on GCP that impact GI. Furthermore, we examine the dynamic effects of GCP on the GI of firms and find out the timeliness of GCP's impact on GI. Based on the empirical findings, we provide solutions to enhance companies' GI in relation to both external institutions and internal CSR.

The succeeding portions of this work are organized in the following way: Section 2 of this research paper comprises a comprehensive literature evaluation and the subsequent creation

of hypotheses. The third section of the document provides a comprehensive overview of the study methodology, data sources, and the precise definitions of variables. The findings derived from the study are provided in Section 4. The robustness tests are covered in Section 5 of the research. Section 6 of the text pertains to the discussion of the findings. Section 7 of the paper serves as the conclusion and the policy implications that stem from the results.

2. Literature review and hypothesis development

2.1. GCP and GI

The Porter hypothesis is a well-established theoretical framework employed in the examination of the link between environmental legislation and industrial innovation. The Porter hypothesis posits that in response to governmental pressures or environmental regulations, firms are inclined to augment their R&D expenditure on pollution control technology and energy-saving technology, resulting in short-term cost escalation. Over time, the combination of technological advancements, improvements in productivity, and enhanced market competitiveness has the potential to generate supplementary returns that surpass the initial investment in R&D. In summary, the hypothesis put forth by Porter posits that the implementation of environmental laws yields advantageous results by fostering inventiveness (Porter & Van der Linde, 1995; Wang et al., 2024). However, whether the Porter hypothesis can be tested or not is highly dependent on the internal and external characteristics of the firm, such as the degree of market competition the company faces and the company's strategy (Shao et al., 2020; W. Zhang et al., 2024).

One view is that GCP policies do promote GI by firms. With strict social supervision and the improvement of the government's environmental laws, companies tend to choose to conduct green technology research and development to avoid environmental pollution and penalties from the government. By actively carrying out green technology innovation, enterprises can not only avoid government penalties but also obtain more sources of financing (Sinha et al., 2021). Moreover, Sinha et al. (2021) constructed a quantile model to study the relationship between the Green Bond Index (GRBI) and the Environmental and Social Responsibility Index (ESRI). They found that at a low level of GRBI and ESRI, the GRBI has a positive impact on the ESRI. However, the impact of GRBI on ESRI is decreasing as both indices rise. They argued that in the absence of policy-level directives to determine sustainability through business operations, companies may use GRBI primarily as a means to save on taxes rather than envisioning it as a tool to generate socio-ecological outcomes. The concept of GCP entails a shift in the financial system's lending practices, wherein projects and enterprises characterized by excessive air pollution and consumption of energy are no longer eligible for loans. Conversely, projects that align with environmentally friendly or green initiatives are more likely to secure funding from both governmental and financial establishments (Peng et al., 2022). Peng et al. (2022) conducted empirical tests by constructing a DID model with a selection of Chinese firms that were listed from 2006 to 2018. They discovered that GCP significantly reduces the debt financing of heavy polluting enterprises (HPEs). However, HPEs see very little impact on their short-term debt financing as a result of GCP. Meanwhile, the decrease in company performance resulted in a financial penalty. GCP incentivizes HPEs to enhance their R&D investment and technical innovation as a means to mitigate the penalty impact. Commercial banks have a greater inclination to provide loans to innovative green projects and companies under the GCP guidelines. From the firm's perspective, GCP implements an external stimulus, similar to an incentive mechanism, and in order to get more

funds, firms have to cater to the government and commercial banks to get more scale of funds (Zhang et al., 2020b). In a study by Zhang et al. (2020b), the researchers looked at the relationship between GI and financing constraints in Chinese non-financial private enterprises listed on the Shanghai and Shenzhen Stock Exchanges from 2012 to 2017. They utilized OLS regression modeling and discovered that GI has the potential to mitigate corporate financing constraints. The regression analysis findings of the study demonstrated that GI, including both green technological innovation and green management innovation, effectively mitigated corporate funding restrictions. From a cost-benefit perspective, companies weigh the payoffs and rewards and then act. GI is a long and risky process, and in the short term, the costs exceed the benefits. Long-term, however, the pressure on businesses from the environment is constant or even rising. Without GI, companies will face high expenses such as environmental taxes, environmental protection expenses, and sewage charges in the long run, so it is a wiser decision for them to choose GI (Hu et al., 2021). Hu et al. (2021) used a DID model to analyze the influence of GCP on the GI of HPEs and explore the policy's consequences. The findings indicated that GCP has a favorable and constructive influence on the green patent production of HPEs. In the context of tighter external financial constraints, GCP produces a greater impact. Therefore, the findings indicated that GCP has the ability to promote environmentally friendly innovation in HPEs by implementing restrictions on financing, thereby facilitating the transition towards sustainability.

China's GCP can be seen as an environmental regulation policy because it requires firms to contribute to environmental improvement in order to obtain bank loans. Su et al. (2022) acknowledged that GCP has the capability to mitigate environmental damage by diminishing airborne contaminants. In the long run, GCP will have a more favorable impact on the environment as the green credit system is improved (Su et al., 2022). Su et al. (2022) used Granger causality, parametric stability tests, and quantile-to-quantile test to examine the association between GCP and air quality from 2003 to 2019. The enhancement of the green credit system has a substantial beneficial effect on air pollution. This study added additional evidence that GCP affects air pollution. Zhang et al. (2022) conducted a study using green credit guidelines as a quasi-natural experiment to investigate the effect of GCP on the carbon emission intensity of HPEs. By using panel data and employing a DID model, the study reveals that the adoption of GCP primarily leads to a reduction in carbon emissions via two primary mechanisms. Qin and Cao (2022) examined whether the implementation of GCP promotes a low-carbon economy. By constructing a DID model, this research determines that the implementation of green financing policies has a significant impact on reducing pollution in businesses.

Based on the aforementioned study, we put forth the subsequent hypothesis:

Hypothesis 1: GCP drives GI in enterprises.

An alternative perspective says that GCP fails to foster corporate GI. In response, companies may embrace environmentally-friendly cleaning practices as a means to circumvent regulatory regulations pertaining to the environment. From the standpoint of the influence of GCP on corporate resources, it can be inferred that GCP implementation will result in a rise in the financial requirements for businesses. Consequently, firms may face constraints in accessing cash within a limited timeframe. Enterprises have a lack of financial resources to undertake GI initiatives due to limited financing channels. Within the GCP, commercial banks extend loans by evaluating the extent to which the revealed information provided by the company aligns with the stipulated GCP criteria. To mitigate the adverse consequences

of a capital deficit, firms may resort to greenwashing tactics within the realm of information disclosure. This strategic approach aims to perplex commercial banks, facilitating the acquisition of credit funds (Dagestani et al., 2024; Kim & Lyon, 2015). Thus, we put forth the subsequent hypothesis:

Hypothesis 2: GCP promotes companies to adopt greenwashing.

2.2. Role of CSR in GCP and GI

CSR is a topic with a long history, and researchers have been studying it for close to 100 years (Berle, 1931; Dodd, 1932; Frederick, 1960). This paper adopts Aguinis' definition of CSR (Aguinis, 2011), which has also been widely accepted by other scholars (E. Rupp, 2011; Williams & Aguilera, 2008): "context-specific organizational actions and policies that take into account stakeholders' expectations and the triple bottom line of economic, social, and environmental performance." As research on CSR deepened, scholars began to conduct research on CSR in terms of specific real-world issues (Belay et al., 2024; Peloza & Shang, 2011). In terms of CSR in the innovation of enterprises, most of the literature concludes that there is a strong link between CSR and corporate GI and that CSR leads to significant improvements in GI (Hao & He, 2022; Forcadell et al., 2021; Mbanyele et al., 2022; Xue et al., 2022; Yuan & Cao, 2022). Empirical studies have found that CSR drives the construction of firms' technological resources, thereby increasing firms' technological efforts, or R&D, and outcomes in product and process innovation. Forcadell et al. (2021) conducted empirical research to examine the connection between CSR and the ability of small and medium-sized enterprises (SMEs) to innovate. They gathered data from a panel of 2,405 SMEs in Spain over a span of eight years. The research discovered that CSR promotes the construction of technological resources in firms. CSR strengthens innovation in firms and promotes innovation in previously non-innovative firms, with effects that persist over time (Forcadell et al., 2021). In further studies, researchers confirm that CSR ultimately improves the market competitiveness of companies by promoting GI and acquiring new core technologies (Padilla-Lozano & Collazzo, 2022). The relationship between CSR and GI becomes even stronger, especially when the government requires businesses to publish CSR-related data. In response, companies seek to embrace strategies that promote GI in order to bolster their CSR credentials (Mbanyele et al., 2022). The GCP has compelled national credit departments to integrate environmental issues into the structure of corporate credit allocation and to provide greater credit resources towards green initiatives. Nevertheless, the presence of information asymmetry in the capital market makes it challenging to accurately assess the environmental performance of enterprises. Consequently, enterprises must employ their own environmentally responsible actions as a means to signal their creditworthiness to financial institutions. Undertaking social responsibility and transmitting green signals to the credit department are considered the most crucial methods in this regard (Liao et al., 2024; Oikonomou et al., 2014). To put it another way, low CSR is a penalty, such as higher financial costs, while high CSR is a reward, such as a good reputation and low capital costs.

Therefore, drawing from the aforementioned study, we put up the subsequent hypothesis:

Hypothesis 3: CSR plays a mediating role in the connection between GCP and GI.

Hypothesis 4: CSR plays a moderating role in the link between GCP and GI.

The above literature review shows that in the past, the influence of corporate GI or greenwashing was generally examined in terms of some aspect of the internal or external factors

of the firm. Based on the past literature, we have constructed a research framework that integrates internal and external influencing factors, as depicted in Figure 1.

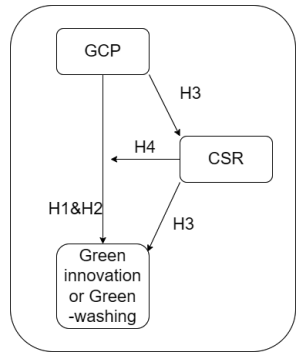

Figure 1. Theoretical hypothesis diagram

GCP is a financial policy based on environmental protection that supports national or regional environmental protection undertakings from the perspective of finance. GCP mainly works by influencing enterprises' decisions related to environmental matters. Capital is the most significant factor that affects enterprises under the GCP. In order to obtain loans from banks, enterprises are bound to cater to the GCP as much as possible. In order to comply with the GCP, there are two main choices for enterprises: one is to carry out GI activities in accordance with the government's requirements in a truthful manner, and the other is to adopt a greenwashing policy, which does not carry out GI but rather decorates the company's data to be in line with the GCP by means of information asymmetry. These two policy choices are closely linked to the CSR of the enterprise. The CSR enables enterprises to make decisions that are more in line with the harmonious development of human beings and the environment, rather than using information asymmetry to seek bank loans. CSR encourages companies to make decisions that are more in line with the harmonious development of human beings and the environment, rather than taking advantage of information asymmetry in order to obtain bank loans.

3. Methodology, data, and variable definition

3.1. Methodology

The DID method is employed in this study to assess the influence of GCP on enterprises' GI. The DID methodology is suitable for the assessment of policy effects of GCP, and some studies have previously used the DID methodology to conduct GCP-related research (Li et al., 2024; Peng et al., 2022; Hu et al., 2021; A. Zhang et al., 2022; Qin & Cao, 2022; Chen et al., 2022). This research examines a total of 5,819 panels of Chinese listed businesses' data spanning from 2009 to 2021. Listed companies on the Shanghai Stock Exchange and Shenzhen Stock Exchange are used as research samples. We divide the sample firms into two groups, HPEs is the treatment group and the other is the control group, and try to analyze the policy effects of GCP using the DID model. The utilization of the propensity score matching (PSM) technique, as introduced by Rosenbaum and Rubin (1983), is employed to match samples in order to mitigate the presence of selective sample bias. This approach ultimately enhances

the dependability of the regression outcomes derived from the DID model. In the process of constructing the empirical model, we set up two types of dummy variables: (1) treatment groups and control groups. Listed companies in heavily polluting industries take 1, others take 0, and (2) time virtual variable. The years 2012 and later are taken as 1, and the years before 2012 are taken as 0.

We followed the literature (e.g., Gao & Wang 2021; Xing et al., 2019) to measure enterprises' GI by the number of green invention patents, and we constructed Model 1 to estimate the impact of GCP on enterprises' GI and greenwashing. We used model 2 to test the moderating impact of CSR, and models 3 and 4 to test the mediating impact of CSR.

$$Ginn_{it}\left(or\,Greenwashing_{it}\right)=\beta_0+\beta_1 Treat_i\times Post_t+Control_{it}+\xi_i+\lambda_t+\varepsilon_{it};\tag{1}$$

$$Ginn_{it}\left(or\ Greenwashing_{it}\right)=\beta_0+\beta_1 Treat_i\times Post_t+\beta_2 CSR_{it}+\beta_3 Treat_i\times Post_t\times CSR_{it}+Control_{it}+\xi_i+\lambda_t+\varepsilon_{it};\tag{2}$$

$$CSR_{it}=\beta_0+\beta_1 Treat_i\times Post_t+Control_{it}+\xi_i+\lambda_t+\varepsilon_{it};\tag{3}$$

$$Ginn_{it}=\beta_0+\beta_1 Treat_i\times Post_t+\beta_2 CSR_{it}+Control_{it}+\xi_i+\lambda_t+\varepsilon_{it},\tag{4}$$

where $Ginn_{it}$ is the degree of GI, $Greenwashing_{it}$ is the degree of greenwashing, $Treat_i$ is the treatment group dummy, $Post_t$ is the time dummy, and $Control_{it}$ are the control variables as shown in Table 1. We further consider firm fixed effects and year fixed effects, and winsorize continuous variables at the 1st and 99th percentiles. In model 3, CSR_{it} is the degree of CSR.

3.2. Variable definition

The dependent variable is the firm's GI, or greenwashing. We quantified the GI of firms by evaluating their use of GI patents ($Ginn_{it}$). Greenwashing refers to a company's attempt to confuse or exaggerate its performance in environmental protection by making symbolic disclosures in the environmental disclosure process (Kim & Lyon, 2015; Walker & Wan, 2012). We refer to He and Gan (2022) to construct evaluation indexes of greenwashing degree based on environmental information disclosure reports of listed companies (He et al., 2022). The specific approach is as follows: a total of 20 disclosure items in the environmental report, with 0 points for no disclosure, 1 point for descriptive disclosure (no specific quantity in the disclosure information), and 2 points for quantitative disclosure (there are specific quantities in the disclosure information). After obtaining the specific scores of listed companies, the degree of greenwashing is calculated by the following formula:

$$SDS=1-\frac{Number\,of\,disclosed\ \ items}{Total\ \ number\,of\,disclosed\ \ items};\tag{5}$$

$$DDS=\frac{Number\ \ of\,symbolic\ \ disclosure\ \ items}{Total\ \ number\,of\,disclosed\ \ items.};\tag{6}$$

$$Greenwashing_{it}=\sqrt{SDS\times DDS}.\tag{7}$$

The aforementioned method utilizes the acronym SDS to represent the selective disclosure score, whereby a higher score signifies a heightened level of selective disclosure exhibited by the organization. The acronym DDS represents the Symbolic Disclosure Score, which serves as a metric for measuring the extent of symbolic disclosure undertaken by a corporation. A higher score on the DDS implies a heightened level of symbolic transparency exhibited by the company. The term "greenwashing" is used to assess the extent of greenwashing, with a higher score indicating a more significant level of greenwashing.

The independent variable is the interaction term among the dummy variable of GCP implementation time and the dummy variable of the HPEs. In terms of control variables, following literature (e.g., Gao & Wang, 2021; Xing et al., 2019; He et al., 2022), we exercise control over a range of variables that have the potential to impact the GI of organizations, including return on assets (*Roa*), liability ratio (*Lev*), firm size (*Lnsize*), firm cash flow level (*Cash*), firm growth (*Gro*), equity concentration (H1), and proportion of independent directors (*Inde*).

Table 1. Variable names and definitions

Variable type	Variable name	Variable symbol	Variable description
Dependent variables	Degree of GI	Ginn	The natural logarithm of the number of green invention patents applied for plus one.
	Degree of greenwashing	Greenwashing	It is calculated by the formula (3)–(5).
Independent variable	The interaction term between HPEs and GCP time.	Treat×Post	***Treat*** is a dummy variable for HPEs. When the industry where the enterprise is located is a heavily polluting industry, take 1, otherwise take 0. ***Post*** is a dummy variable for the implementation time of GCP, take 1 in 2012 and after, otherwise take 0.
Control variables	Profitability	Roa	Net profit divided by total assets
	Debt level	Lev	Total liabilities divided by total assets
	Enterprise size	Lnsize	Natural logarithm of total assets
	Cash flow	Cash	Net cash flow from operating activities divided by total operating revenue
	Growth	Gro	Operating income growth rate.
	Concentration of shareholding	H1	Shareholding ratio of the largest shareholder
	Percentage of independent directors	Inde	Number of independent directors divided by total number of board of directors

In the empirical model later, we study Ginn and Greenwashing as dependent variables, respectively, to clarify how GCP affects the two and to dig out the role played by CSR in it.

3.3. Data

We choose all publicly traded firms in China as our sample. Because, in order to observe the effect of GCP on respondents' GI, we need to analyze the difference between respondents' GI before and after the implementation of GCP. However, if the comparison is only before and after the GCP, there will be serious errors, because, as time moves, the external environment

is changing, and respondents will also be affected by other factors on GI, which means that the difference between respondents before and after the implementation of the GCP cannot be determined to be entirely due to the GCP. That is to say, the difference between respondents before and after the implementation of GCP cannot be determined to be entirely brought by the GCP, and the policy effect of GCP cannot be judged correctly. Then, we need to divide the respondents into two groups, one is the treatment group, who will be affected by the GCP, and the other is the control group, which is not affected by the GCP. Observe the changes in GI in the treatment and control groups before and after the implementation of GCP, respectively. The change in GI in the treatment group is produced by a combination of GCP and other factors. The change in GI in the control group is not brought about by GCP, because this sample is not affected by GCP and it is the change in GI brought about by other factors. Finally, we can isolate the policy effects of GCP by differencing the changes in GI in these two samples. The data of enterprises' GI is obtained from the China National Intellectual Property Administration (CNIPA) and the World Intellectual Property Organization (WIPO). The following methods were used to exclude: (1) Excluding enterprises that have been listed for less than one year; (2) excluding enterprises with incomplete data on key variables; and (3) excluding listed companies marked as ST or ST* (Special Treatment) by the exchange, which have a higher risk of delisting. By using the above method, we obtained a total of 5819 company-year observations.

4. Empirical results

4.1. Descriptive statistics

Table 2 displays the descriptive statistics. The variable Ginn exhibits a sample mean of 0.988, a median of 0, a standard deviation of 1.333, a minimum value of 0, and a maximum value of 5.425. These statistics suggest significant variations in green invention patents among different organizations, with around 50% of companies not making considerable innovations. Regarding the phenomenon of greenwashing, it is seen that the upper limit for greenwashing is 0.5, while the median value stands at 0.400. This implies that almost half of the companies exhibit a greenwashing level that is near the maximum value of 0.5.

Table 2. Descriptive statistics

Variable	Mean	Median	S.D.	Minimum	Maximum	Observations
Ginn	0.988	0.000	1.333	0.000	5.425	5819
Greenwashing	0.366	0.400	0.116	0.000	0.500	5819
Treat×Post	0.303	0.000	0.460	0.000	1.000	5819
Roa	0.039	0.033	0.050	–0.153	0.196	5819
Lev	0.501	0.515	0.193	0.069	0.885	5819
Lnsize	23.405	23.297	1.463	20.562	27.349	5819
Cash	0.109	0.090	0.175	–0.555	0.702	5819
Gro	0.278	0.117	0.686	–0.630	4.411	5819
H1	37.566	36.534	15.724	7.840	74.820	5819
Inde	4.127	4.000	1.291	2.000	8.000	5819

From the descriptive data analysis, it is not clear whether firms' GI and greenwashing are affected by GCP, and further analysis is needed later.

4.2. Main results

Table 3 reports the results of the baseline regression. The dependent variables in columns (1)–(3) are GI. The regression results in columns (1)–(3) show that the regression coefficients of *Treat*×*Post* are significantly positive, indicating that GCP has a positive effect on the GI of enterprises. The dependent variables in columns (4)–(6) are the degree of greenwashing. The regression results in columns (4)–(6) show that the regression coefficient of *Treat*×*Post* is not significant. Consequently, hypothesis 1 is supported by the empirical analysis.

Table 3. Baseline results

	Ginn			*Greenwashing*		
	(1)	(2)	(3)	(4)	(5)	(6)
Treat×*Post*	0.526*** (0.000)	0.205*** (0.000)	0.203*** (0.000)	0.00747 (0.317)	0.00602 (0.435)	0.00632 (0.413)
Roa		–0.545* (0.091)	–0.478 (0.136)		–0.0103 (0.817)	–0.0141 (0.751)
Lev		–0.836*** (0.000)	–0.786*** (0.000)		–0.00436 (0.852)	–0.00667 (0.780)
Lnsize		0.709*** (0.000)	0.694*** (0.000)		0.00407 (0.333)	0.00475 (0.262)
Cash		–0.0304 (0.637)	–0.0358 (0.574)		–0.0171 (0.135)	–0.0166 (0.147)
Gro		0.0132 (0.456)	0.0159 (0.368)		–0.00295 (0.218)	–0.00302 (0.210)
*H*1			–0.00589* (0.053)			0.000222 (0.510)
Inde			0.00314 (0.679)			–0.000962 (0.388)
Constant	0.828*** (0.000)	–15.23*** (0.000)	–14.69*** (0.000)	0.364*** (0.000)	0.275*** (0.004)	0.255*** (0.010)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5819	5819	5819	5819	5819	5819

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and P values in parentheses.

A model (8) was developed in order to examine the dynamic effects of GCP on the GI of enterprises. The findings of the regression analysis, which include time-dynamic changes, are presented in Table 4. The regression findings presented in columns (1) indicate a statistically significant and positive relationship between GCP and meaningful GI within HPEs. The regression coefficient of $Treat \times After^3$ is significantly positive, which means that in the third year after the implementation of GCP, the GI achievements of enterprises are reflected, indicating that it takes time to produce the effect of GCP, and it takes a long time to carry out the layout of innovation activities, which cannot be done in a short time. Furthermore, the strength of this relationship is observed to increase over time. The regression analysis in column (2) reveals that the adoption of GCP leads to an initial increase in corporate greenwashing activity. However, this effect diminishes as time progresses.

$$Ginn_{it} = \beta_0 + \beta_1 Treat_i \times Before^{-2} + \beta_2 Treat_i \times Before^{-1} + \beta_3 Treat_i \times Current^0 + \beta_4 Treat_i \times After^1 + \beta_5 Treat_i \times After^2 + \beta_6 Treat_i \times After^3 + \beta_7 Treat_i \times After^4 + \beta_8 Treat_i \times After^5 + \beta_9 Treat_i \times After^6 + \beta_{10} Treat_i \times After^7 + \beta_{11} Treat_i \times After^8 + \beta_{12} Treat_i \times After^9 + Control_{it} + \xi_i + \lambda_t + \varepsilon_{it}. \quad (8)$$

$Before^{-2}$ and $Before^{-1}$ are indicator variables that equal one if the observation is the second and first year before GCP implementation and zero otherwise, respectively. $Current^0$ is an indicator variable that equals one if the observation is in the GCP implementation year and zero otherwise. $After^1$, $After^2$, $After^3$, $After^4$, $After^5$, $After^6$, $After^7$, $After^8$ and $After^9$ are indicator variables that equal one if the observation is the first, second, third, fourth, fifth, sixth, seventh, eighth and ninth year after the GCP enacts and zero otherwise, respectively.

Table 4. Results of regression based on time dynamic changes

	Ginn	*Greenwashing*
	(1)	(2)
Treat×*Before*$^{-2}$	–0.0285 (0.791)	0.0152 (0.384)
Treat×*Before*$^{-1}$	0.115 (0.280)	0.0262 (0.109)
Treat×*Current*^{0}	0.130 (0.222)	0.0274* (0.091)
Treat×*After*^{1}	0.150 (0.144)	0.0192 (0.222)
Treat×*After*^{2}	0.153 (0.136)	0.0261 (0.101)
Treat×*After*^{3}	0.233** (0.029)	0.0290* (0.063)
Treat×*After*^{4}	0.175* (0.088)	0.0216 (0.179)
Treat×*After*^{5}	0.245** (0.024)	0.0147 (0.374)
Treat×*After*^{6}	0.302*** (0.008)	0.0242 (0.128)
Treat×*After*^{7}	0.360*** (0.002)	0.0125 (0.460)
Treat×*After*^{8}	0.410*** (0.000)	0.0246 (0.142)
Treat×*After*^{9}	0.348*** (0.003)	0.00827 (0.621)
Control variables	Yes	Yes
Constant	–13.97*** (0.000)	0.211** (0.044)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	5819	5819

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and *P* values in parentheses.

Figures 2 and 3 below contrast the dynamic differences between GI and greenwashing influenced by GCP. From the comparison of Figures 2 and 3, it becomes evident that there is a significant disparity in the influence of GI as determined by GCP. The impact of GCP on GI is gradually strengthening, while the impact of GCP on greenwashing is gradually disappearing.

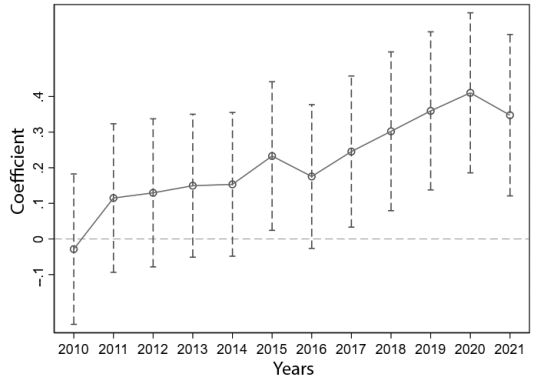

Figure 2. Regression coefficient of *Ginn*

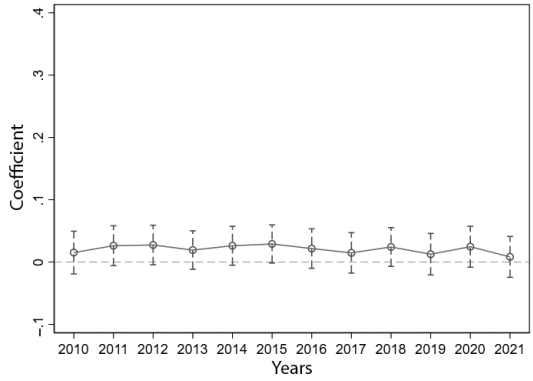

Figure 3. Regression coefficient of *Greenwashing*

From the baseline regression results, GCP does promote firms to carry out GI, but it does not have a significant effect on firms' greenwashing behavior. From the dynamic regression results, the effect of GCP on enterprises to carry out GI gradually strengthens over time, which may be related to the Chinese government's increasing attention to environmental regulation in recent years. The effect of GCP on enterprises' greenwashing behavior was very small; the regression coefficient is always around 0 in Figure 3.

4.3. Verifying parallel trend assumption

We followed Fang et al. (2014) and tested that GIs satisfy parallel trends, that is, the average change in GI before GCP implementation has the same trend in the treatment and control groups. Following Fang et al. (2014), we constructed model (8), and according to the regression findings presented in Table 4 above, we can determine that the regression coefficients for both $Before^{-2}$ and $Before^{-1}$ were not significant before the implementation of GCP.

There was evidence suggesting that both the treatment and control groups exhibited similar patterns of GI.

4.4. Mediating effect test

To test whether GCP indirectly influences GI through CSR, i.e., to test the mediating role of CSR. We constructed models 3 & 4. The regression findings of the mediating effects model are presented in Table 5. From the empirical results, the regression coefficient of *Treat×Post* in the first column shows a statistically significant positive value, suggesting that GCP has a positive and beneficial influence on CSR. The regression coefficient of CSR in the second column has a statistically significant positive value, suggesting that CSR has a favorable influence on GI. Therefore, we can determine that there is a mediating effect of CSR in GCP influencing GI, i.e., H3 is confirmed.

Table 5. The regression findings of the mediating effects model

	CSR	*Ginn*
	(1)	(2)
Treat×Post	0.601* (0.059)	0.175*** (0.001)
CSR		0.019*** (0.000)
Control Variables	Yes	Yes
Constant	17.312*** (0.000)	–14.937*** (0.000)
Year FE	Yes	Yes
Firm FE	Yes	Yes

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and *P* values in parentheses.

The dependent variables in columns (1) and (2) of Table 5 are CSR and GI, respectively. From the regression results of baseline results, the total effect produced by GCP is 0.226; from Table 5, we can see that the direct effect of GCP is 0.175, and the indirect effect of GCP through CSR is 0.601*0.019 = 0.011. It can be concluded that the indirect effect accounts for the total effect of 5.1%.

4.5. Moderating effect test

Model 2 was developed to estimate the moderating influence of CSR on the relationship between GCP and GI. The regression findings of the moderating effects model are presented in Table 6. The results indicate that the regression coefficient for the interaction term between Treat, Post, and CSR is statistically significant and positive. This suggests that CSR has a moderating role in the relationship between GCP and GI in firms. Therefore, hypothesis 4 is supported. The model coefficient for the interaction term between Treat, Post, and CSR in column (2) demonstrates a statistically significant negative relationship. These findings indicate that CSR has a moderating effect on the impact of GCP on deceptive environmental marketing practices, often known as greenwashing behavior. Specifically, an increase in CSR activities can effectively deter firms from engaging in greenwashing.

Table 6. The regression findings of the moderating effects model

	Ginn	*Greenwashing*
	(1)	(2)
Treat×Post	0.184*** (0.001)	0.00429 (0.580)
CSR	0.00345 (0.316)	0.000628 (0.264)
Treat×Post×CSR	0.0493*** (0.000)	–0.00176** (0.037)
Control Variables	Yes	Yes
Constant	–14.34*** (0.000)	0.286*** (0.008)
Year FE	Yes	Yes
Firm FE	Yes	Yes

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and *P* values in parentheses.

The dependent variables in columns (1) and (2) of Table 6 are green invention and greenwashing, respectively. Derivation of $Treat_i \times Post_t$ inside model 2 yields the following equation:

$$\frac{\partial Ginn_{it}}{\partial (Treat_i \times Post_t)} = \beta_1 + \beta_3 CSR_{it} = 0.184 + 0.0493 CSR_{it}. \quad (9)$$

The derivative of CSR_{it} in equation (9) gets the following equation:

$$\frac{\partial \left(\frac{\partial Ginn_{it}}{\partial (Treat_i \times Post_t)} \right)}{\partial CSR_{it}} = 0.0493. \quad (10)$$

The coefficient of 0.0493 in equation (10) indicates a positive and statistically significant relationship. This means that as the degree of CSR increases, it strengthens the impact of GCP on GI. The regression coefficient of the interaction term *Treat×Post×CSR* in column (1) exhibits a statistically significant positive relationship. This suggests that as the level of CSR increases within the GCP implementation, there is a greater propensity for fostering major GI inside firms. In column (2), the regression coefficient for the interaction term *Treat×Post×CSR* is –0.00176. This suggests that as CSR increases, enterprises are more discouraged from engaging in greenwashing within the framework of GCP implementation.

4.6. Underlying plausible mechanism

According to China's environmental subsidy policy, we hypothesize that the HPEs will encourage GI behavior in enterprises by using government innovation subsidies as a means of promotion. By using equations (11) and (12), we examine if the HPEs possess the aforementioned pathways to have an impact on enterprises' innovation.

$$Subsidies_{it} = \beta_0 + \beta_1 Treat_i \times Post_t + Control_{it} + \xi_i + \lambda_t + \varepsilon_{it}; \quad (11)$$

$$Substantive\_inn_{it} = \beta_0 + \beta_1 Treat_i \times Post_t + \beta_2 Subsidies_{it} + Control_{it} + \xi_i + \lambda_t + \varepsilon_{it}. \quad (11)$$

The findings from analyzing the fundamental channels are shown in Table 7. The variables of interest in column (1) are the innovation subsidies provided to enterprises by the government. The regression findings in column (1) indicate that the regression coefficients of *Treat*×*Post* are considerably positive, suggesting a considerable rise in government innovation subsidies to the HPEs. *Ginn* are the dependent variables in column (2). The regression analysis in columns (2) reveals that the regression coefficients for subsidies exhibit a statistically significant positive relationship, suggesting that government subsidies serve as a crucial mechanism for the promotion of GI by HPEs.

Table 7. Verifying the underlying channel

	Subsidies	*Ginn*
	(1)	(2)
Treat×*Post*	1.638*** (0.007)	0.197*** (0.001)
Subsidies		0.004* (0.089)
Control variables	Yes	Yes
Constant	1.682 (0.767)	-14.8699*** (0.000)
Year FE	Yes	Yes
Firm FE	Yes	Yes

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and *P* values in parentheses.

In recent years, the Chinese government has been paying more and more attention to environmental issues and has continued to give subsidies to companies in order to promote innovation and change their previous heavy reliance on resources and negative impact on the environment. Through the analysis of the underlying channel above, we can make it clear that an important reason why Chinese firms do not choose greenwashing behavior under the GCP is that the government is continuously giving subsidies to firms for GI, thus promoting firms to ultimately choose GI.

5. Robustness tests

5.1. PSM-DID test

This research used the PSM method and the DID approach to evaluate the impact of GCP on GI, with the aim of improving the credibility of the results. Figure 4 demonstrates that the disparities in variables between the treatment and control groups were significantly mitigated with the implementation of PSM. The figures, specifically Figure 5 and Figure 6, illustrate that the distributions of the treatment and control groups exhibit a high degree of proximity to one another after using the PSM method. The results of the DID analysis following PSM are presented in Table 8. In the first column, the regression coefficient of the interaction term between *Treat* and *Post* demonstrates a statistically significant positive effect. This suggests that the implementation of GCP has a major impact on fostering GI in firms.

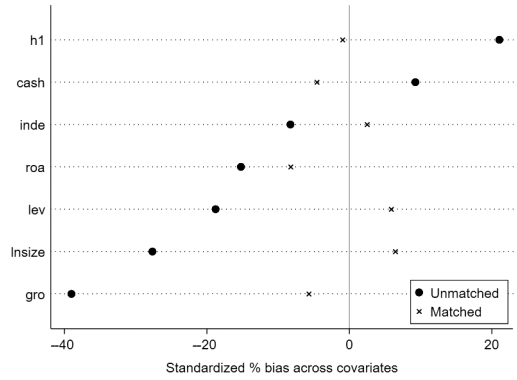

Figure 4. Variable differences before and after matching

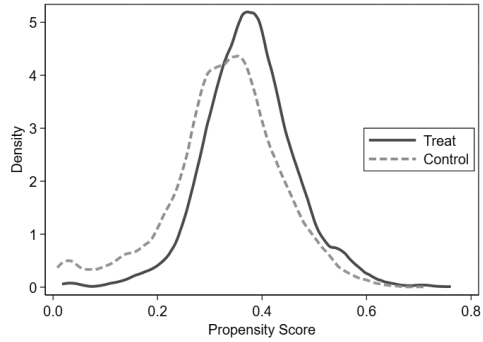

Figure 5. Density of the treatment group and control group before matching

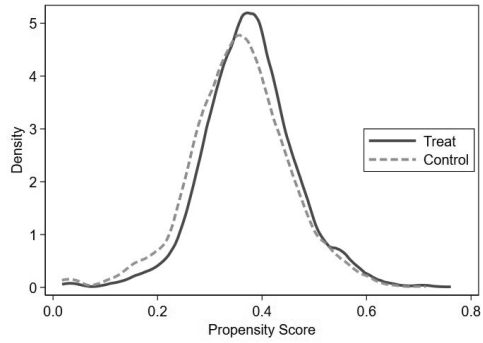

Figure 6. Density of the treatment group and control group after matching

By conducting a rigorous robustness test, we establish that CSR significantly impacts enterprises' GI within the GCP. Based on the empirical findings, it can be inferred that CSR has a beneficial impact on GCP. It encourages companies to choose GI while discouraging them from engaging in deceptive greenwashing practices.

Table 8. Regression results of PSM-DID

	Ginn	*Greenwashing*
	(1)	(2)
Treat×Post	0.150*** (0.002)	0.00121 (0.858)
CSR	0.00492 (0.211)	0.000313 (0.577)
Treat×Post×CSR	0.0543*** (0.000)	-0.00134 (0.128)
Control Variables	Yes	Yes
Constant	−14.61*** (0.000)	0.276*** (0.003)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	5819	5819

Note: ***, **, * indicate significant at 1%, 5%, 10% confidence level, and P values in parentheses.

5.2. Placebo test

In order to better accurately demonstrate the impact of the GCP, we implemented a placebo test. The t-value of the policy impact is determined by randomly picking businesses as the treatment group and cycling them 1,000 times. This information is shown in Figure 7. Figure 7 illustrates that the t-value is mostly centered around 0. However, in the actual scenario, the t-value for the policy impact of GCP is 3.16, indicating that its coefficient is not statistically significant at the 95% confidence level when firms are randomly allocated as the treatment group. Therefore, it demonstrates that the promotion of GI in organizations has a tangible impact in the real world, and this impact is not only by chance.

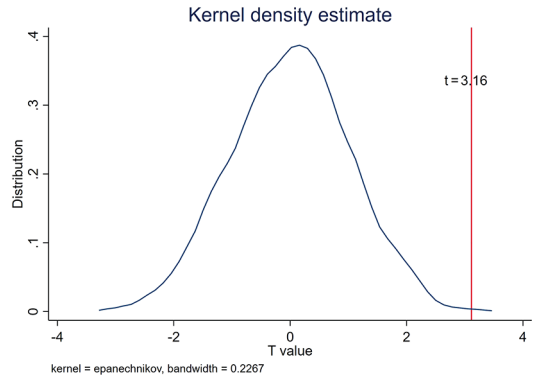

Figure 7. The result of placebo test

With the placebo test, we can see that this positive effect produced by GCP is not a co-incidence of data but is true in real-life situations. This is because in randomly selected firms, artificially assigning GCP did not yield significant results on GI.

6. Discussion

This research used the PSM-DID approach to investigate the correlation between GCP and GI. In table 8, the regression coefficient for the interaction term between *Treat* and *Post* is 0.15. This coefficient has a substantial and beneficial impact on the GI. By using the DID technique, the regression coefficient of *Treat*×*Post* incorporates the 15% rise in GI resulting from the influence of the GCP on the treatment group compared to the control group. The regression coefficient of *Treat*×*Post*×*CSR* in the DID model represents the moderating effect of CSR. In Table 8, the regression coefficient of *Treat*×*Post*×*CSR* is 0.0543, which means that the greater the CSR, the greater the effect of GCP on GI. In model 3, the regression coefficient of *Treat*×*Post* is 0.601, which means that GCP has a significant positive effect on the CSR of enterprises. In model 4, the regression coefficient of CSR is 0.019, which indicates that CSR has a positive impact on GI. The combined regression results of models 1, 3, and 4 imply that GCP has an indirect effect on GI through CSR. The study's results provide many significant discoveries. Our research demonstrated that the influence of GCP on enterprises' GI is limited by CSR.

First, the findings suggest that GCP does promote firms' GI rather than greenwashing. The decisions that companies make in GI and greenwashing are influenced by factors internal and external to the company, and the decisions that companies ultimately choose produce long-term benefits for them (He et al., 2022).

Second, our findings also suggest that the Porter hypothesis is applicable in China. The Porter hypothesis suggests that when facing policy pressure or environmental regulation, enterprises will choose to increase their R&D investment in pollution control technology and energy-saving technology (Porter & Van der Linde, 1995). GCP could be perceived as an environmental regulatory policy that requires firms to contribute to environmental improvement in order to obtain bank loans. Enterprises will strategically prioritize GI as a means to mitigate the potential adverse effects of environmental regulatory regulations and prevent substantial limitations on future financing (Chen et al., 2022; Su et al., 2022; Zhang et al., 2022).

Third, among the factors external to the enterprise, government subsidies are a key factor in guiding companies to make the right decisions. Companies are forced to adopt greenwashing due to financial pressure as they are unable to actively carry out GI activities through their own strengths as their short-term funding sources are more restricted due to GCP policies. Green technology innovation related to environmental protection has externalities and high risks. The initial investment in GI activities for highly polluting companies far exceeds the benefits they receive. In terms of externalities, GI by enterprises will lead to an increase in overall social benefits (Chenguang & Yong'an, 2014). Therefore, GI cannot be accomplished entirely by market forces, especially after the implementation of GCP. The Chinese government has further compressed the funding sources of highly polluting industries, which inhibits their enthusiasm to carry out GI activities. The effective alignment between GCP and innovation subsidy policy can effectively address the challenges faced by firms. The innovation subsidy policy, being a significant measure implemented by the Chinese government, plays a crucial role in promoting and incentivizing company innovation (Guan et al., 2019).

Ultimately, our findings demonstrated a significant correlation between the influence of GCP on corporate GI and CSR. Consistent with the findings of Hao and He (2022). CSR plays a very important role in promoting substantial innovation in enterprises and inhibiting them from adopting greenwashing to obtain funding. CSR, in conjunction with GCP, may significantly enhance GI inside firms.

7. Conclusions and policy implications

We aimed to assess the influence of GCP on the firm's GI. In summary, we tested the impact of external policies on firms' innovative behavior and identified the moderating role of firms' CSR on policy effects. The GI behavior of enterprises is closely related to external systems and internal factors, and to promote the GI of enterprises requires joint efforts from both internal and external aspects of enterprises. The limitation of this study is that our findings apply only to developing countries, and the gradual strengthening of GCP effects over time that we find is closely related to the characteristics of developing countries. Developing countries are generally weaker in terms of technology, finance, and hardware, and the realization of transformation, upgrading, and GI will take a long time to develop and accumulate. In developing countries, government innovation subsidies are an important mechanism for GCP to promote GI in enterprises. GI is an important way to promote sustainable development in developing countries. As global climate change and resource constraints intensify, GI has become a focus of attention for governments and businesses. By promoting GI, developing countries can reduce environmental pollution and resource consumption, improve economic efficiency and competitiveness, and also contribute to global environmental protection. Developing countries have a number of problems and challenges in implementing GI and environmental protection. This research of ours provides new ideas to activate the vitality of GI in developing countries. To promote sustainable development in developing countries and contribute to global environmental protection through the formulation of green policies and the creation of a corporate CSR system.

Through the analysis and demonstration of the correlation between GCP and corporate GI, we may formulate significant suggestions. GCP implementation directly affects the funding sources of companies, which can lead to their inability to innovate quickly enough to adopt greenwashing in the short term. As a result, the GCP will be much less effective in the early years and not meet the government's expectations. Such policies are expected to promote GI by enterprises, reduce their pollution, and thus protect the environment. However, the policies themselves can affect the funding sources for enterprise innovation, so it is recommended that enterprises be given sufficient transition periods before implementing such policies to allow them enough time to prepare in advance so that they can successfully complete the strategic shift when the policies are implemented. When implementing GCP, the government gives companies a transition period of 3–5 years to avoid financial difficulties.

In order to achieve the reduction of environmental pollution, we should start from within the enterprise, and we will get better results if we improve the CSR in China. China is still a developing country. Thirty years ago, China began to reform and open, transitioning from a planned economy system to a market economy system. For a long time, China emphasized rapid economic development and neglected corporate CSR. As China's economic level rises, it has begun to improve corporate CSR, which is conducive to the green transformation of the economy and environmental protection. China's market economy system is not yet mature, and CSR cannot be formed by entrepreneurs themselves. The government plays a leading role in the development of the market economy, and the government should actively guide enterprises to build good CSR. Through the improvement of the supporting system and CSR, enterprises can be prevented from adopting greenwashing as much as possible.

With regards to limitations and future research, it is important to note that our study primarily focused on China as a case study. To get a more comprehensive understanding of the impact of GCP on corporate GI, it would be beneficial to validate our findings across other nations.

For future research, the scope of the study could be expanded to include several categories of countries, both developed and developing. The relationship between CSR and GI can be further refined in terms of the institutional and cultural context of the country to contribute to the sustainable development of mankind.

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Disclosure statement

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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