



# Corporate social responsibility, financing constraints, and corporate carbon intensity: new evidence from listed Chinese companies

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## Abstract

Corporate social responsibility (CSR) is becoming increasingly important in the field of corporate sustainability. However, little literature has focused on the relationship between CSR and corporate carbon emissions in developing countries. This paper aims to fill this gap by exploring the relationship between CSR and corporate carbon intensity from the perspective of financing constraints. We examine the mediating effects of financing constraints using a mediating effects model by using Chinese listed companies data from 2011 to 2019. The analysis results of this paper are as follows: (1) CSR can reduce corporate carbon intensity. (2) Financing constraints have a positive mediating role between the two. Namely, CSR can reduce the financing difficulties of enterprises, and enhance carbon-neutral capacity. (3) The carbon emission reduction effect of CSR is different in different life cycles. (4) CSR has a greater impact on the carbon intensity of state-owned enterprises, high-tech enterprises, and heavy polluting enterprises. These facts provide meaningful references for developing countries such as China to promote CSR and carbon governance.

**Keywords** Corporate social responsibility · Corporate carbon emissions · Financing constraints · Mediation effect model

## Introduction

Enterprises are the major emitters of environmental pollution. In 2019 China National Energy Administration reported that corporate energy consumption accounted for 70% of total energy consumption and generated more than 50% of GHGs (Zheng and Walsh 2019; Ren et al. 2022). With the awakening of environmental awareness, external stakeholders such as the government, the public, and the media begin to pay attention to corporate environmental governance, calling on companies to change their traditional profit-first business strategies, actively participate in CSR(Corporate Social Responsibility) activities and establish environmental management systems to achieve the goal of carbon neutrality.

CSR is an effective corporate strategy to achieve sustainability in the economy environment and society (Schönherr et al. 2017). CSR can improve the image and competitiveness of a company (Al Mubarak et al. 2018). A good social image and an improved work environment can attract highly qualified talents (Albinger and Freeman 2000). CSR can also improve firm performance by changing the financial status (Javed and Husain 2021). It can be seen that existing CSR studies have focused on aspects such as corporate performance and competitiveness, which few studies have explored the impact on corporate carbon emissions (Schönherr et al. 2017). Two existing known papers on carbon emissions focus on developed countries. Fukuda and Ouchida (2020) developed a three-stage game model of monopolist CSR and found that CSR can promote social good but increase carbon emissions. Doda et al. (2016) measured corporate carbon emissions data by using the Carbon Disclosure Project, and investigated the impact of corporate carbon management practices on carbon emissions in 2009 and 2010, and found that corporate carbon management practices did not reduce carbon emissions as much as expected. Compared to companies in developed countries that are at or moving towards the Industry 4.0 stage, companies in developing countries such

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as China are still in the industrial stage of high consumption and high emission. Therefore, how CSR strategies affect corporate carbon emissions and achieve sustainable development are the central question in this paper.

Environmental governance is accompanied by high costs (Bauer and Hann 2010), and CSR strategies can build bridges between firms and external stakeholders and reduce the burden on firms. Financing constraints reflect the relationship between CSR and external stakeholders (Ikram et al. 2019). Existing studies have focused on exploring CSR and financing constraints, financing constraints, and carbon emissions, which rarely explored the relationship among the three. Zhao and Xiao (2019) found that CSR is negatively related to financing constraints, i.e., CSR can alleviate the financing constraints of enterprises. Yu et al. (2022) used a panel of industrial enterprise data during 2001–2012 to construct an evaluation system of enterprise pollutant emission intensity using principal component analysis and found that financing constraints increase enterprise pollutant emissions. It can be seen that there is a “blind box” in the study of CSR, financing constraints, and corporate carbon emissions. Therefore, it is valuable to investigate whether CSR affects corporate carbon emissions through financing constraints.

The purpose of this study is to analyze the impact of CSR on corporate carbon emissions based on Chinese listed companies data and to verify whether financing constraints have a mediating effect on the relationship between CSR and carbon emissions. The following key questions are to be answered: does CSR reduce corporate carbon emissions? Does financing constraint have a positive mediating effect? Taking 1798 Chinese listed firms during 2011 and 2019 as the study population to answer the above questions. The stability of the regression results is also tested by using the instrumental variables approach. In addition, CSR strategies are just starting in Chinese companies, therefore, the effects of CSR need to be further determined.

This paper supplements the existing literature in three ways. First, the relationship between CSR and corporate carbon emissions and the mediating role of financing constraints are analyzed from stakeholder theory and resource dependence theory. Second, considering that corporate carbon emissions are closely related to the corporate life cycle, the impact of CSR on carbon emissions under different stages is explored, which can allow corporate managers to understand the effect of CSR more intuitively so as to adjust CSR strategies accurately. Finally, the carbon emission reduction effect of CSR is explored based on enterprise heterogeneity. This study extends the study of CSR and corporate carbon emissions to emerging developing countries, which provides an effective solution for corporate carbon governance.

## Theoretical analysis and hypothesis

### CSR and corporate carbon intensity

Many scholars believe that corporate involvement in CSR can not only reduce pollutant emissions but also can it lead to sustainable financial growth (Asongu 2007). According to stakeholder theory, instead of being isolated, companies are closely linked to the external environment. Business managers need to balance the relationship between the company and external stakeholders to ensure stakeholders' rights and meet stakeholders' needs (Burga and Rezaia 2017). CSR can reduce the information inequality between the company and external stakeholders (Strambach 2017), increase investors' confidence, and thus achieve strategic goals, such as transformation and upgrading, digital strategy, innovation strategy, and environmental strategy (Jamali 2007). CSR represents a company's commitment to its stakeholders (Taghian et al. 2015). In recent years, with the awakening of environmental awareness among the government, public, and media, more and more stakeholders have become concerned about corporate environmental governance capabilities. So companies are trying to gain stakeholders' support to conduct environmental governance (Chen et al. 2015). Tang and Tang (2012) surveyed 300 SMEs based on stakeholder theory and found that the differences between stakeholder and corporate power, stakeholder CSR orientation has a positive impact on corporate environmental performance. Nazari et al. (2017) used 1180 US companies data from 2008 to 2013 as the study population and found that expanding CSR disclosure can significantly improve corporate environmental performance. The cited author noted that CSR can increase the credibility of external stakeholders such as shareholders, financial analysts, and investors and expand investment efforts. Anser et al. (2020) investigated 324 hotels and found that the direct impact of CSR commitment on environmental performance was positive and significant.

Most CSR studies have mainly used survey methods to construct environmental performance systems, which very little literature has directly measured corporate carbon emissions. Therefore, exploring the relationship between CSR and carbon emissions can provide us with a visual representation of the actual effects of CSR. The existing literature on measuring corporate carbon emissions mainly comes from life cycle estimation, indirect measurement, and input–output analysis (Huang et al. 2009; Dong et al. 2013). Carballo Penela et al. (2009) proposed a top-down approach to obtain an organization's carbon footprint based on a product life cycle measurement. Wong et al. (2022) developed a new input-process-output carbon footprint measurement model to obtain the carbon footprint of each

stage. Considering the availability of data, the corporate carbon emissions were estimated by using the industry-level economic input–output cycle approach (EIO-LCA) combined with the firm-level conversion method (Chapple et al. 2013). Based on the above theory, the hypothesis is proposed.

H1: CSR can reduce corporate carbon intensity.

### The moderating impact of financing constraints

CSR is closely linked to external stakeholders and financing constraints can explain the degree of external stakeholders' involvement based on stakeholder theory and resource dependence theory. CSR can help companies build a good social image and increase their chances of obtaining external financing (Zhao and Xiao 2019). In addition, CSR can reduce information asymmetry between external stakeholders and firms, which can allow investors to understand the dynamic changes in firms and increase investment opportunities, which in turn reduces the difficulties of corporate financing (Cheng et al. 2014). Boubaker et al. (2020) surveyed 1201 US listed companies from 1991 to 2012 and found that better CSR performance led to companies to have good reputations as well as better financing ability. External stakeholder involvement can bring diversity of resources, such as technology, management philosophy, interpersonal contacts, and environmental thinking. These “heterogeneous” resources can reduce the cost of implementing new strategies and upgrading, creating new green profit points for the company, and achieving financial and environmental sustainability (Khan et al. 2021). Kassinis and Vafeas (2006) found that stakeholders bring heterogeneous resources to the firm and facilitate the transformation and upgrading of the firm, thus realizing the dual goals of carbon reduction and high profitability (Rodriguez-Melo and Mansouri 2011). Wang et al. (2022) used 290 cities data in China from 2004 to 2017 and found that financing constraints limit cities' access to external finance, which is detrimental to their high-quality development. The cited authors mention that financing constraints can limit urban green innovation, which in turn can affect carbon emissions. Based on the above theory, we propose the hypothesis.

H2: Financing constraints have a negative mediating role in CSR and carbon intensity.

### Variable description and methodology

Our original sample consists of manufacturing companies listed on the Shanghai and Shenzhen stock exchanges in China from 2011 to 2019, with corporate data from China Stock Market & Accounting Research Database (CSMAR),

carbon emission data from the China Carbon Accounting Database, and other data from the China Statistical Yearbook. On the one hand, the availability of carbon emission data is taken into account, as well as the exclusion of the impact of the novel coronavirus pandemic in 2020. So we choose the data from 2011 to 2019. On the other hand, manufacturing enterprises are the main carbon emission subjects. Therefore, we only study manufacturing enterprises. After excluding the sample of enterprises with serious missing information, we obtain 11,123 annual observations of enterprises.

The dependent variable in this paper is corporate carbon intensity (CCI), which is measured as the ratio of corporate carbon emissions to operating income. Existing studies measuring corporate carbon emissions are mainly based on social responsibility report disclosure, life cycle approach, and IPCC approach (Konadu et al. 2022; Wei et al. 2022). Considering that CSR reports in China do not disclose corporate carbon emissions and the availability of data, corporate carbon emission data are obtained from the sub-sector carbon emission data released by the China Carbon Accounting Database. The China Carbon Accounting Database is a carbon emission disclosure platform operated by Tsinghua University, the Ministry of Science and Technology, and others (Shan et al. 2018), which measures province-level, city-level, and sub-sector carbon emissions using a multi-scale carbon emission accounting method (Chen, 2022). Our research selected sub-sector carbon emission data were calculated based on carbon emissions from direct fossil combustion and indirect production processes (Wei et al. 2022; Guan et al. 2021). First, we matched the sub-sector carbon emission data with the panel data of listed companies (based on industries). Then, corporate carbon emission data were calculated based on the ratio of industry operating costs to company operating costs.

$$CE_i = C_j \times O_i / O_j \quad (1)$$

where  $CE_i$  is the carbon emission of corporate  $i$ ;  $C_j$  is the total carbon emission of sector  $j$ ;  $O_i$  is the operating costs of corporate  $i$ ;  $O_j$  is the total cost of central business of sector  $j$  to which corporate  $i$  belongs

$$CCI_{i,t} = CE_{i,t} / OI_{i,t} \quad (2)$$

where  $CCI_{i,t}$  is the carbon intensity of corporate  $I$  in year  $t$ ;  $CE_{i,t}$  is the carbon emission of corporate  $I$  in year  $t$ ;  $OI_{i,t}$  is the operating income of corporate  $I$  in year  $t$ .

The independent variable in this paper is CSR performance, which comes from the CSR index published by Hexun (Wen and Song 2017). This index includes shareholder responsibility, employee responsibility, supplier,

customer, and consumer rights responsibility, environmental responsibility, and social responsibility. To explore the impact of CSR on the CCI, the following model was developed (Cook et al. 2019)

$$CCI_{i,t} = \alpha_0 + \beta_0 CSR_{i,t} + \sum_{i=1}^6 \gamma_i \text{control} + \epsilon_{i,t} \quad (3)$$

To explore how CSR affects firms' carbon intensity, financing constraints are introduced as a mediating variable. As mentioned in Sect. 2.2, CSR reduces the information opposition between firms and external stakeholders and increases investors' investment confidence. In this paper, we try to explain external stakeholder involvement through financing constraints (Zhang et al. 2020) and use the KZ index to measure corporate financing constraints (Liu et al. 2021). the higher the KZ value, the more severe the corporate financing constraints, indicating less stakeholder involvement. The following mediating effect model is developed.

$$KZ_{i,t} = \alpha_0 + \beta_0 CSR_{i,t} + \sum_{i=1}^6 \gamma_i \text{control} + \epsilon_{i,t} \quad (4)$$

$$CCI_{i,t} = \alpha_0 + \beta_0 CSR_{i,t} + \beta_1 KZ_{i,t} + \sum_{i=1}^6 \gamma_i \text{control} + \epsilon_{i,t} \quad (5)$$

where CCI is the corporate carbon intensity, CSR is the corporate social responsibility index and KZ is financing constraints. Based on the studies of Zhao and Xiao (2019), Zhu et al. (2016) and He et al.(2021), the control variables selected were as follows. Size (log of firm's total assets), Growth (growth rate of operating income), Age (log of firm's age), Lev (ratio of total liabilities to total assets), Liq (ratio of current assets to total assets), Fix (ratio of net fixed assets to total assets). In addition, we control for industry and time effects with clustering at the firm level to remove the effect of unobserved factors on the regression results. Table 1 shows the descriptive statistics for all variables, and it can be seen that there are significant differences between firms.

**Table 1** The descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CCI	11,123	0.210	0.619	0.002	4.357
CSR	11,123	23.417	16.167	-17.19	90.87
KZ	11,123	0.697	2.083	-9.802	10.348
Age	11,123	2.762	0.368	1.099	3.951
Growth	11,122	0.205	1.324	-0.95	82.7
Size	11,123	22.112	1.172	17.641	27.468
Lev	11,123	0.403	0.192	0.064	0.845
Liq	11,123	0.233	0.226	-0.242	0.728
Fix	11,123	0.236	0.138	0.0002	0.833

## Regression results and discussion

### Baseline analysis

Table 2 provides the regression results after gradually fixing individual effects, time effects, and control variables. Our regression results tell us that CSR can significantly reduce the corporate carbon intensity. Taking column (4) as an example, the regression results with the inclusion of control variables and fixing individual and time effects. the coefficient of CSR is -0.0003 on CCI at 5% significant level. This finding is contrary to that of Doda et al. (2016) but validates our hypothesis H1. These results indicate that CSR can significantly reduce corporate carbon intensity. In other words, companies that engage in CSR to achieve corporate carbon neutrality.

### The mediating effect of financing constraints

Table 3 shows the impacts of financing constraints on the relationship between CSR and CCI. In general, CSR can significantly reduce the corporate financing constraint (-0.011,  $p < 0.001$ ); the higher the financing constraint, the higher the corporate carbon intensity (0.005,  $p < 0.001$ ), which validates our hypothesis H2. There is a

**Table 2** Baseline regression result

	(1)	(2)	(3)	(4)
Variables	CCI	CCI	CCI	CCI
CSR	-0.0011*** (0.000)	-0.0009** (0.000)	-0.0017*** (0.0005)	-0.0014** (0.0005)
Age		0.050*** (0.016)		0.055** (0.024)
Growth		0.015*** (0.004)		0.011 (0.007)
Size		0.028*** (0.006)		-0.010 (0.011)
Lev		0.244*** (0.052)		0.158* (0.093)
Liq		-0.020 (0.049)		0.010 (0.071)
Fix		0.931*** (0.053)		0.094 (0.124)
Con	0.236*** (0.010)	-0.845*** (0.130)	0.280*** (0.020)	0.241 (0.232)
Industry	No	No	Yes	Yes
Year	No	No	Yes	Yes
Obs	11,123	11,122	11,123	11,122
R-sq	0.001	0.070	0.592	0.596

\*\*\*, \*\*, \* indicate significance at the level of 1%, 5%, and 10%

**Table 3** Mechanism of action of CSR

Variables	KZ	CCI
KZ		0.006** (0.003)
CSR	-0.024*** (0.001)	-0.0013*** (0.0003)
Con	10.294*** (0.612)	0.182* (0.096)
Control	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
Obs	11,122	11,122
R-sq	0.558	0.596
Total effect	CSR → CCI(without KZ)	-0.0014**(0.0001)
Direct effect	CSR → CCI	-0.0013***(0.0003)
Indirect effect	CSR → KZ → CCI	-0.0001**(0.00006)
Bootstrap test(1000)	CSR → KZ → CCI	-0.0001*** (0.00006)

\*\*\*, \*\*, \* indicate significance at the level of 1%, 5%, and 10%

significant negative mediating impact of financing constraint between CSR and CCI. The bottom part of Table 3 shows the direct, indirect, and total effects of CSR. It can be seen that the direct, indirect, and total effects of CSR are significantly negative and the direct effect is larger than the indirect effect. Bootstrap test also indicates that financing constraints have a negative mediating effect.

### Endogeneity and robustness test

We use corporate ESG scores disclosed by Bloomberg to replace CSR (Pyles 2020). The regression results in Table 4 indicate that ESG has a significant negative effect on corporate carbon intensity. Considering the possible endogeneity, we choose whether the firm is audited by 4 Big accounting firms (Big4) as the instrumental variable (Hao and He 2022). The social responsibility reports developed by Big 4 accounting firms are more trustworthy and do not affect corporate finances. We used the WW index to replace the KZ index to test the mediating role of the financing constraint (Altomonte et al. 2016). Unlike the KZ index, which considers only the firm’s own characteristics, the WW index also considers the firm’s external characteristics and more accurately estimates the financing constraint. In the first stage, it can be seen that the CSR can be improved by big4 audit, moreover, the *F*-value is 29.40 much greater than 10 and the choice of instrumental variables is valid. In the second stage, our regression results are consistent with Tables 2 and 3. In addition, the inclusion of the WW index in the model indicates that our findings are stable and plausible.

### Further analysis

#### Corporate life cycle test

Corporate carbon intensity is closely related to the corporate life cycle, we divided the sample into 5 stages: introduction, Growth, Mature, Shake out, and Decline (Bansal and

**Table 4** Endogeneity and robustness test

Variables	Replace independent variable	First stage	Second stage	Mediating variable: WW	
				CCI	WW
CSR			-0.033*** (0.012)	-0.0006*** (0.00005)	-0.001** (0.001)
ESG	-0.001*** (0.0003)				
WW					0.028* (0.086)
Big 4		3.548** (1.296)			
Con	0.176*** (0.042)	-83.449*** (5.801)	-2.695** (1.129)	0.070*** (0.018)	0.245* (0.251)
Control	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
F-statistic		29.40			
Obs	11,122	11,122	11,122	9,559	9,559
R-sq	0.926	0.253	0.596	0.558	0.602

\*\*\*, \*\*, \* indicate significance at the level of 1%, 5%, and 10%



Thenmozhi 2020). Table 5 provides the results of the impact of CSR under each stage. Overall, the impact of CSR on the carbon intensity is negative at all stages. At the introduction stage, CSR is  $-0.0014$  on CCI at 10% significant level. At the growth stage, CSR is  $-0.0007$  on CCI. At the mature stage, CSR is  $-0.0010$  on CCI at 1% significant level. At the shake-out stage, CSR is  $-0.0024$  on CCI at 1% significant level. At the decline stage, CSR is  $-0.0045$  on CCI at 5% significant level. In addition, Table 5 also provides the average carbon intensity under each stage and found that the corporate carbon intensity fluctuated around 0.20. These facts show that the carbon reduction effect of CSR increases as corporations move into the decline stage.

### Corporate heterogeneity test

Considering that different types of companies have different attitudes towards CSR and the intensity of their carbon emissions. Therefore, we conducted sub-sample regressions based on state-owned enterprises and non-state-owned enterprises (SOE and non-SOE), high-tech enterprises and

non-high-tech enterprises (HTE and non-HTE), and heavily polluting enterprises and non-heavily polluting enterprises (PE and non-PE). The regression results in Table 6 show that CSR has a negative impact on carbon emissions for all types of businesses. And CSR has a greater impact on carbon emissions of PE, HTE, and SOE.

## Discussion

This study fills a gap in research on CSR and carbon emissions in developing countries. CSR can reduce corporate carbon emissions and achieve corporate sustainable development. In addition, financing constraints have a positive mediating effect. Considering that corporate carbon intensity is closely related to the life cycle, the subsample regression results indicate that the effect of CSR on corporate carbon intensity ranges from small to large, including the stages of introduction, growth, matured, shock out, and decline. One possible explanation is that in the early stage of a firm's establishment, they tend to adopt a profit maximization

**Table 5** The impact of CSR under the corporate life cycle

Variables	Introduction CCI	Growth CCI	Mature CCI	Shake out CCI	Decline CCI
CSR	$-0.0014^*$ (0.0008)	$-0.0007$ (0.0005)	$-0.0010^{***}$ (0.0004)	$-0.0024^{***}$ (0.0008)	$-0.0045^{**}$ (0.0019)
Con	0.332 (0.287)	$-0.059$ (0.161)	$0.406^{***}$ (0.145)	$-0.116$ (0.255)	0.178 (0.571)
Average CCI	0.220	0.199	0.220	0.196	0.232
Control	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Obs	1314	3569	4268	1501	440
R-sq	0.605	0.604	0.614	0.654	0.670

\*\*\*, \*\*, \* indicate significance at the level of 1%, 5%, and 10%

**Table 6** The impact of CSR under corporate heterogeneity

Variables	(1) PE CCI	(2) Non-PE CCI	(3) HTE CCI	(4) Non-HTE CCI	(5) SOE CCI	(6) Non-SOE CCI
CSR	$-0.0030^{***}$ (0.0006)	$-0.0003^{**}$ (0.0001)	$-0.0021^{***}$ (0.0006)	$-0.0009^{***}$ (0.0002)	$-0.0004^{**}$ (0.0002)	$-0.0003^{**}$ (0.0002)
Con	$0.227^*$ (0.120)	$0.058^{**}$ (0.023)	$0.757^{***}$ (0.118)	0.023 (0.034)	$0.087^{***}$ (0.152)	0.087 (0.152)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Obs	4330	6792	3975	7147	4279	6843
R-sq	0.575	0.146	0.658	0.528	0.610	0.593

\*\*\*, \*\*, \* indicate significance at the level of 1%, 5%, and 10%

strategy to maintain viability. As environmental management requires sacrificing some economic benefits, firms do not voluntarily disclose environmental management through CSR (Yunus et al. 2010; Allet and Hudon 2015). In contrast, after companies enter the shock-out and decline stage, companies gradually have an advantage in the economic market, and the marginal benefits brought by environmental management gradually outweigh the marginal costs. And for early mass-produced products, production models and corporate strategies are difficult to maintain corporate competitiveness, while companies that engage in CSR can bring new profitability and thus achieve sustainable development (Belenzon et al. 2019). In other words, early in the life cycle, firms received little attention from stakeholders, and business managers tended to adopt a sloppy operating model to increase market share. Whereas, after firms enter the shock-out, and decline stage, increasing financial, technological, and peer competition pressures make it difficult to continue their dominant position, but CSR strategies can mitigate this conflict. For example, the environmental needs and resource availability of external stakeholders will drive companies to adopt strategies such as transformation and upgrading, green innovation, and environmental management.

The results of the enterprise heterogeneity analysis show that CSR has a greater impact on carbon intensity in state-owned enterprises, high-tech enterprises, and heavy polluting enterprises. For SOEs, the explanation is that SOEs often take on important social responsibility and political tasks because of their special social status. SOEs will actively adopt CSR strategies to establish a “leading role” and help drive CSR in all kinds of enterprises (Zhu et al. 2016). For high-tech enterprises, the explanation is that HTEs have high technology levels (Sun et al. 2021), which can mitigate information asymmetries of external stakeholders and capture public environmental demands (Chien et al. 2021), and CSR can coordinate the technological advantages of HETs to achieve cleaner production, such as environmental management, industrial upgrading, and dynamic capabilities. For heavy-polluting enterprises, the explanation is that PEs get environmental pressures from society and government, which force firms to adopt aggressive environmental strategies to maintain their legitimacy and competitiveness (Delmas and Toffel 2004).

In summary, this paper confirms the carbon reduction effect and mechanism of CSR action based on stakeholder theory and resource dependence theory. Second, the effects of CSR are different under different life cycles. Finally, the carbon governance effect of CSR has firm heterogeneity. These facts suggest that firms adopting CSR strategies is an important means to achieve carbon neutrality. CSR achieves corporate carbon emission reduction by balancing the information asymmetry between firms and external stakeholders and alleviating corporate financing constraints. This study

provides unique insights into CSR disclosure and carbon emission reduction in emerging developing countries such as China.

## Conclusions and limitations

This paper provides a direction to promote corporate CSR and carbon reduction. This is the first study that explores the impact of CSR on corporate carbon intensity in developing countries from a stakeholder perspective. Using a fixed-effects model, we explored the carbon emission reduction effect and action mechanism of CSR for Chinese-listed companies from 2011 to 2019. The analysis results of this paper are as follows: (1) CSR can reduce corporate carbon intensity. (2) Financing constraints have a positive mediating role between the two. Namely, CSR can reduce the financing difficulties of enterprises, and enhance carbon-neutral capacity. (3) The carbon emission reduction effect of CSR is different in different life cycles. (4) CSR has a greater impact on the carbon intensity of state-owned enterprises, high-tech enterprises, and heavy polluting enterprises. These facts provide meaningful references for developing countries such as China to promote CSR and carbon governance.

Based on these results, the following recommendations are proposed. For the government. The government should encourage companies to adopt CSR activities in order to integrate all kinds of resources from shareholders, public, society, and community, etc. Second, they should establish and improve information disclosure platform to enhance the credibility of enterprises' information. Third, the government should provide precise support for different life-cycle enterprises, and improve the motivation of enterprises in the early stage to conduct CSR strategies. For business managers. In addition to the government's mandatory CSR disclosure, enterprise managers should fully understand the effectiveness of CSR and voluntarily disclose CSR. Second, enterprises should publish dynamic information to the society in a timely manner to alleviate information asymmetry and attract social capital to join in. Third, corporate managers should not only focus on short-term gains but also take social responsibility into account. For example, while pursuing high profits, enterprises in the early stage should also actively participate in CSR and establish a good brand reputation to achieve sustainable corporate development. Finally, business managers should recognize that carbon emission reduction by CSR has firm heterogeneity. Non-state owned enterprises, non-high-tech enterprises, and heavy polluting enterprises who are in the market and policy gap should actively disclose CSR to attract the attention of external stakeholders and achieve the nationwide carbon neutrality goal.

There are still some limitations in this study. First, this paper uses the EIO-LCA method to construct firm-level carbon emissions, so that the measured firm carbon emissions may be biased. Second, this paper uses financing constraints to measure external stakeholder participation, which ignoring the mediating role of other variables, such as governance costs and agency costs. Finally, this paper only focuses on the effect of CSR on corporate carbon intensity and the mechanism of action, ignoring the possible dynamic effect of CSR. In future research, we will further explore the relationship between CSR and carbon emissions.

**Author contribution** PC is an independent author and has done all the work.

**Data availability** The datasets generated during and/or analyzed during the current study are available in the WIND and CSMAR (China Stock Market & Accounting Research Database).

## Declarations

**Ethics approval and consent to participate** Not applicable.

**Consent to Participate** Not applicable.

**Consent for publication** Not applicable.

**Competing interests** The author declares no competing interests.

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