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Corporate environmental governance and firm value: beyond greenwashing for sustainable development

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Abstract

Corporate greenwashing is becoming more common as a result of companies' growing awareness of the need to protect the environment and help to achieve the Sustainable Development Goals. This study analyzes the relationship between corporate environmental governance (CEG) and firm value from short- and long-term perspectives. It is based on balanced panel data of 575 Chinese-listed companies in high-polluting industries from 2012 to 2018. The findings demonstrate that, first, there is no correlation between CEG and firm value during either the current or the first lag period, suggesting that corporate environmental governance has no discernible short-term effects on company value. Second, in the second and third eras, there is a noteworthy positive association between CEG and company value, suggesting that, over time, corporate environmental governance can considerably raise the business's future value. Corporate environmental governance significantly increases business value over the long run. This study goes beyond only offering greenwashing; instead, it offers some policy implications for businesses to be sustainable.

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1 Introduction

Corporate greenwashing and the methods implemented by companies to improve the sustainability of the planet are increasing (Ruiz-Blanco et al., 2022; Yousaf et al., 2023; Yu et al., 2020). In many companies, greenwashing is used, and numerous corporate actions are employed to present a public image that is environmentally responsible and respectful of the natural environment (Li et al., 2023). In many cases, it is only a matter of appearance, and companies try to bet on corporate social responsibility to attract more customers or have a better image. They try to offer consumers products enhancing minimal or non-existent ecological qualities, which has sometimes led to a growing skepticism about the green claims of institutions (Lu et al., 2021; Nishitani et al., 2021). Greenwashing as a business strategy can fail if there is a loss of trust by customers and suppliers in the company's environmental policies.

With all of the issues we are facing, like biodiversity loss, climate change, and environmental degradation, environmental conservation is becoming more and more crucial (Cifuentes-Faura, 2021; Wang et al., 2023). Given the importance and the need to achieve sustainable development of the planet, in 2015, the United Nations (UNs) approved the 2030 Agenda (Cifuentes-Faura, 2022a, 2022b; Simionescu et al., 2023). This Agenda is a plan of action to enhance people's well-being, planet, prosperity, peace, and work together (Lafuente-Lechuga et al., 2020). It will enable the promotion of more just and sustainable societies and will require the participation of all countries, citizens, and stakeholders, including companies and businesses around the world (Khurshid et al., 2023; Lorente et al., 2023).

The 2030 Agenda also brought about the adoption of the 17 Sustainable Development Goals (SDGs), which include eradicating climate change (SDG 13), achieving "economic growth and decent work" (SDG 8), developing "sustainable cities" (SDG 10), and having "responsible production and consumption" (SDG 12) (Sharma et al., 2023; Simionescu & Cifuentes-Faura, 2023; Uche et al., 2023).

Companies play a key role in environmental protection and can contribute to it by promoting sustainable practices, products, and services (Pizzi et al., 2020; Zhang et al., 2023). Businesses should maximize their value as an objective of corporate governance, so corporate environmental governance of companies can favor the creation of value for the company, beyond its greenwashing policies. Many companies focus on responding to social demands, getting involved in ethical and social issues, and assuming a real commitment to respect for the environment, far from mere appearance.

China's economy has grown steadily faster since reform and opening up. However, environmental issues including overuse of resources and ecological destruction have accompanied China's economic growth (Wang et al., 2017). China's economic development now mainly focuses on green development, which is pioneering high-quality economic development. Enterprises are not only the main generators of environmental degradation, but also the direct architects of social wealth. According to the "polluter governs" principle, companies should be in charge of environmental governance. Although companies have generally believed that environmental governance brings less economic benefits and reduces productive investment, this belief has led to an unwillingness to implement environmental governance due to the public goods attributes and externalities of the ecological environment, as well as the characteristics of long investment cycles and the high cost of environmental governance (Orsato, 2006).

The aim of corporate governance is to maximize firm value; therefore, the question of whether corporate environmental governance (CEG) can facilitate the creation of corporate value emerges (Whittingham et al., 2023). Is it possible for companies to benefit the environment and the economy at the same time? The response to this query will enable businesses to investigate methods of achieving sustainable development and will aid in their correct comprehension of the connection between CEG and firm value. Despite the abundance of research on the subject, most of it has examined the relationship between CEG and enterprise value in the short term. Very few, however, have looked at the influence of CEG on company value over the long run. Previous research has failed to adequately elucidate the connection between firm value and CEG.

The contributions of this paper focus mainly on two areas: First, an analytical framework is introduced to examine the relationship between CEG and firm value in short and long run. This framework not only examines the relationship from a short-term perspective, but also confirms the long-term lagged effect of the positive impact of CEG on firm value, thus broadening the research perspective of the existing literature. Second, this study addresses the long-term cumulative impact of CEG on business value, further corroborating the lagged effect of CEG on firm value.

The remainder of the document is structured as it. In the next section, we present the literature review and the research hypotheses. After that, we present the sample selection, variable definition, and model specifications. Next, we show the results of the empirical tests and descriptive statistics. Subsequently, we provide the results of a more detailed analysis. Finally, we show the conclusions and the main implications of our study.

2 Literature review and hypothesis

2.1 Corporate environmental governance and firm value

The relationship between CEG and firm value has always been a controversial topic in theory and practice (Jara et al., 2019). Many researchers have undertaken empirical assessments of this relationship, yielding mixed results. Some researchers find a positive correlation between CEG and firm value with the Porter hypothesis (Chen & Ma, 2021; Shabbir & Wisdom, 2020; Yadav et al., 2015) or resource-based view (Clarkson et al., 2011; Jorge et al., 2015; Utomo et al., 2020). Porter's hypothesis states that stringent environmental regulations boost corporate innovation and efficiency, enhancing competitiveness. A strict environmental regulation encourages greater business investment in the study and use of cleaner technologies with a benefit to the environment on the one hand and innovation and improvement of more efficient production processes on the other. The company can cover the costs of innovation as well as the expenses incurred to comply with the new regulations on its own, directly increasing the company's competitiveness.

Hassel et al. (2005) and Makni et al. (2009), based on the trade-off theory that corporates environmental governance and economic benefits cannot be balanced, come to the conclusion that the two constructs are negatively correlated. In addition, some researchers, such as Elsayed and Paton, (2005) or Iwata and Okada, (2011), find no significant association between CEG and firm value. To a large extent, the reasons for the inconsistent conclusions of different studies may be due to the different measurement methods of the research variables, sample sizes, sample industry or sample country differences, different

model settings, and endogeneity without considering reverse causality (Busch & Hoffmann, 2011; Li et al.,2020).

The aforementioned researchers investigate the direct linear relationship between firm value and corporate environmental governance. According to Pekovic et al. (2018) and Trumpp and Guenther (2017), there is a nonlinear correlation rather than a straightforward linear one between CEG and firm value. Fujii et al. (2013) and Pekovic et al. (2018), for instance, find a nonlinear inverted U-shaped association between CEG and firm value based on the theoretical hypothesis of a "too-much-of-a-good-thing" effect; there is a critical optimal point for investment in corporate environmental governance, and when it is below the critical optimal point, CEG is positively related to the value of the firm. The cost of environmental governance outweighs the benefits to the environment when corporate environmental investment surpasses the optimal critical point, which has a detrimental impact on firm values. Trumpp and Guenther (2017), in contrast to Fujii et al. (2013), find that, based on the theoretical hypothesis of a "too-little-of-a-good-thing" effect, the relationship between firm value and CEG is U-shaped. This indicates that there is a "threshold" at which the positive effects of CEG on firm value stop; that is, if corporate environmental governance falls short of the threshold, it will have a negative correlation with firm value; a positive correlation with firm value can only occur if the threshold is crossed.

Although many researchers have studied the relationship between CEG and enterprise value, it needs further discussion given the inconsistent research conclusions, including positive correlation, negative correlation, "U"-type, and inverted "U"-type findings. Existing studies have concluded that corporate environmental governance and firm value are positively correlated, mainly based on short-term static research methods; that is, from a static point of view when examining the linear association between corporate environmental governance and current firm value. We argue that the conclusion that corporate environmental governance and firm value are positively correlated in the current period is not in line with the reality of most enterprises, because if corporate environmental governance could straightforwardly improve the current firm value, then enterprises would be highly motivated to engage in environmental governance activities. However, in reality, the current willingness of companies to actively pursue environmental governance is low (Liu et al., 2022; Orsato, 2006; Sakamoto et al., 2019), unless they receive subsidies for it (Bai et al., 2019), and environmental pollution in enterprises is commonplace. Corporate environmental governance is more likely to increase costs to enterprises in the short run, while in the long term, whether corporate environmental governance is conducive to enhancing enterprise value requires further exploration. We conduct a systematic study on the relationship between CEG and firm value, with a focus on greenwashing and short- and long-term perspective.

3 Research hypotheses

Corporate environmental governance has a long investment cycle, high costs, and positive externalities. Firms must use their limited funds to introduce expensive environmental protection equipment, clean production technology, and build pollution control and prevention and treatment projects with long investment cycles. The large amount of capital expenditure required in the initial stage may squeeze the production and operation funds, increase the operation burden of enterprises, and increase the production costs of enterprises (Clarkson et al., 2004), which is going to negatively affect the output

efficiency of companies in the short term. The positive corporate reputation formed by corporate environmental governance is an intangible asset that is difficult for the market to effectively identify, and its value is easily underestimated by the capital market in the short term (Cai & He, 2014), limiting the short-term value creation of corporate environmental governance. Thus, society benefits more from corporate environmental governance in the short term than companies themselves.

If the cost of CEG is higher than the benefits in the long run, rational firms will naturally reduce their investment in environmental governance, and investors will tend not to choose enterprises with the higher investment in environmental governance as investment objects. According to Cai and He (2014), the environmental performance rating data obtained from the "Kinder, Lydenberg, and Domini" database in the United States show that green investment by investors has grown over the past 20 years, and the number of firms moving toward green practices has also been increasing, which suggests that corporate environmental governance may be conducive to the creation of the long-term value of companies. Porter and Linde (1995) believe that pollution is the inefficient use of resources by firms and a form of waste, and point out that firms could improve resource productivity through innovative practices such as waste recycling, production process improvement, and green product research and development to achieve a win–win situation for firms and the environment. Porter and Linde (1995) use a multi-case approach to illustrate how firms can improve resource productivity and firm competitiveness through environmental governance innovation. For example, the Thermal Power Group in Massachusetts, USA, has taken the lead in developing new de-inking technologies, enabling enterprises to use recycled paper more widely, reduce waste, improve resource efficiency, and reduce production costs. Many listed companies in China have adopted similar practices, such as carbon emission-reduction projects carried out by Shanghai Chlor-Alkali Chemical Company every year, which generate a considerable income. In 2017, the Shanghai Chlor-Alkali Chemical Company implemented six energy-saving and emission-reduction projects, including waste heat recovery and comprehensive utilization of a hydrochloric acid synthesis furnace in Phase I, which directly created 20 million yuan of economic benefits. The above example shows that corporate environmental governance is not only a cost input, but also an output that can bring direct economic benefits to firms. However, corporate environmental governance requires a high capital expenditure at the beginning of the period, and its intangible assets are easily underestimated by the capital market. Therefore, the positive impact of environmental governance on business value creation may lag behind investment, and in the short term, the economic benefits of corporate environmental governance may not effectively compensate for the high cost. In the long run, energy-saving and emission-reduction, recycling of waste into resources, and reduction in environmental violation costs, as well as the improving understanding of corporate environmental governance globally over time, mean that the short-term undervaluing of intangible assets may be corrected by the market in the future and fed back into the company's stock price (Cai & He, 2014). This can help to promote the long-term value of enterprises, which may enable firms to obtain significant long-term returns from environmental governance.

Based on the above analysis, the promotion effect of CEG on enterprise value lags behind investment. In the short term, corporate environmental governance is not conducive to enterprise value creation; however, in the long run, corporate environmental governance is conducive to enhancing future enterprise value. Therefore, the following two hypotheses are proposed:

Hypothesis 1 Current corporate environmental governance negatively affects the current firm value.

Hypothesis 2 Corporate environmental governance has a positive impact on future company value; that is, corporate environmental governance lags behind the promotion of firm value. Corporate environmental governance is conducive to promoting firm value creation in the long run.

4 Method

4.1 Sample selection

As major polluters of the ecological environment, heavy-pollution industry enterprises are the main object of environmental protection department supervision, media, and public concern. Therefore, this paper selects heavy-pollution industry enterprises in China as the research object. We select the listed companies in Shenzhen and Shanghai from 2012 to 2018 as the research sample after eliminating the "Special treatment" (ST) or "Particular transfer" (PT) categories, those with a lack of variable data and those whose industry changed during the sample period from one with heavy pollution to one without, or vice versa. Lastly, balanced panel data with 4025 effective observations covering 575 listed companies in heavy-pollution industries over 7 years, from 2012 to 2018, are obtained.

The following techniques are primarily used to collect the sample data: (1) The annual reports of listed businesses provide the variable data for CEG. In order to obtain the environmental capital expenditure data, which represents the variable of enterprise environmental governance, we collect data on the growth of environmental investment projects at sample companies from the notes on construction in progress in the annual reports of the companies. (2) The "China Stock Market and Accounting Research" database provided the firm value and control variable data. The continuous variables are winsorized at 1 and 99% to prevent the impact of abnormal values of research variables on the study's findings.

4.2 Measurement of variables

Firm value is the dependent variable (Tbq). Referring to the research of Wong et al. (2021), Lai et al. (2022), and Seth and Mahenthiran (2022), Tobin's Q, which reflects the market value of enterprises, is selected to measure the value of enterprises. Tobin's Q can be defined as the ratio of an enterprise's total market value to its asset replacement cost. The market values of circulating stocks, non-circulating stocks, and liabilities make up an enterprise's total market value. Tobin's Q not only considers the current financial situation of the enterprise, but also considers the future market situation of the enterprise, which can reflect the stock price fluctuation of the capital market, represents the long-term feedback results of the capital market for the enterprise value. Therefore, compared with "Return on Assets" (ROA), "Return on Equity" (ROE), or other profitability indicators, Tobin's Q is seen to be a superior indicator of company value and performance (Li et al., 2020) and is the most commonly used index to measure firm value (Jo & Harjoto, 2011).

The independent variable is corporate environmental governance (Env). There is no generally recognized way to quantify corporate environmental governance because it is hard to get data at the company level (Hu et al., 2022). Hu et al. (2020) and Li and

Lu (2016) use environmental capital expenditure to measure corporate governance. Therefore, this paper also uses environmental capital expenditure to measure corporate environmental governance. To control the impact of firm size on environmental capital expenditure, the environmental capital expenditure is standardized based on the total assets at the final of the period. Because the standardized value is too small, to make the empirical results easier to observe and analyze, the standardized environmental capital expenditure is multiplied by 100.

We also control for a list of variables found to be determinants of firm value in previous literature (e.g., Jo & Harjoto, 2011; Seth & Mahenthiran, 2022), such as firm size (Size), nature of property rights (State), ownership concentration (Top1), firm growth (Grow), cash holdings (Cash), and firm age (Age). In addition, we include both time period and industry affiliation to control for possible year-to-year and industry-to-industry variations in firm value.

Table 1 contains the precise definitions used in this paper for the dependent, independent, and control variables.

4.3 Regression Model

According to the theoretical analysis, this paper constructs these models to test the hypotheses:

Firstly, to test hypothesis 1, we construct a regression model (1):

$$
\begin{aligned}
\text{Tbq}_{i,t} = &\alpha_0 + \alpha_1 \text{Env}_{i,t} + \alpha_2 \text{Size}_{i,t} + \alpha_3 \text{Lev}_{i,t} + \alpha_4 \text{State}_{i,t} + \alpha_5 \text{Top1}_{i,t} + \alpha_6 \text{Grow}_{i,t} \\
&+ \alpha_7 \text{Cash}_{i,t} + \alpha_8 \text{Age}_{i,t} + \lambda_1 \sum_{k=1}^{7} \text{Ind}_k + \eta_1 \sum_{y=1}^{6} \text{Year}_y + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

In model (1), Env refers to corporate environmental governance. Size represents firm size. Lev denotes financial leverage. State corresponds to the nature of property rights. Top1 symbolizes equity concentration. Grow signifies firm growth. Cash is the cash holdings. Age represents firm age. $\varepsilon_{i,t}$ is the error term, including unobservable individual effects and purely random error terms.

Secondly, to test hypothesis 2, we construct the following regression model (2):

$$
\begin{aligned}
\text{Tbq}_{i,t} = &\beta_0 + \beta_1 \text{Env}_{i,t-j} + \beta_2 \text{Size}_{i,t} + \beta_3 \text{Lev}_{i,t} + \beta_4 \text{State}_{i,t} + \beta_5 \text{Top1}_{i,t} + \beta_6 \text{Grow}_{i,t} \\
&+ \beta_7 \text{Cash}_{i,t} + \beta_8 \text{Age}_{i,t} + \lambda_2 \sum_{k=1}^{7} \text{Ind}_k + \eta_2 \sum_{y=1}^{6} \text{Year}_y + \varepsilon_{i,t}
\end{aligned}
\tag{2}
$$

Model (2) differs from model (1) in two aspects: First, model (2) introduces a lag number J ($J = 1, 2, 3$) to explain the CEG (Env), and uses the CEG with lag 1, lag 2, and lag 3 as explanatory variables from a long-term perspective, to observe the differences in the impact of corporate environmental governance on future firm value. Second, the number of panel data model periods constructed by model (2) is different from that constructed by model (1). When the number of lag periods is 1, the number of sample periods of model (2) is one period less than that of model (1), and when the number is 2, it is two periods less, and so on.

Table 1 Variables definition

Variable type	Name	Symbol	Definition
Dependent variable	Firm value	Tbq	"(Number of tradable shares×price per share+number of non-tradable shares×net assets per share+book value of liabilities)/book value of total assets"
Independent variable	Corporate environmental governance	Env	(Increase in environmental capital expenditure/total assets)×100
Control variables	Firm size	Size	Total assets (logarithm)
	Financial leverage	Lev	Total Liabilities/total Assets
	Property rights	State	If the company is state-owned, a dummy variable with value one; if not, it has value zero
	Ownership concentration	Top1	Shareholding ratio/largest shareholder
	Firm growth	Grow	The growth rate of the operating income
	Cash holdings	Cash	(Cash+cash equivalents)/total assets
	Firm age	Age	Logarithm number of years since the creation of a company
	Industry (dummy variable)	Ind	Eight industries in total, set up seven industry-dummy variables
	Year (dummy variable)	Year	Seven years in total, set up 6-year-dummy variables

5 Results

Table 2 shows the descriptive statistical results. More than 75% of listed Chinese companies have a market value higher than their book value. This can be checked by the mean value of firm value (Tbq) of 1.998 and the 1/4 quantile of 1.194. Corporate environmental governance (Env) has a mean value of 0.529, a median of 0, and a minimum (maximum) value of 0 (6.536). These values suggest that pollution companies in China have a low overall level of environmental governance, and that there are not many enterprises involved in environmental governance. Size and Lev have mean values of 22.461 and 0.431, respectively. The mean value of state is 0.484, indicating that the proportion of state-controlled firms is 48.4%.

5.1 Hypothesis testing

This paper's first hypothesis examines the connection between contemporary CEG and present firm value. Based on the above-constructed model (1), the fixed effect model estimation method is chosen to perform a regression test on the research sample using the *F*, BP, and Hausman tests.

Table 3 shows that while the current corporate environmental governance's (Env) regression coefficient is negative, it is not statistically significant, suggesting that the current Env has no appreciable influence on the firm's current value. Thus, the first hypothesis is disproved. Although some firms engage in environmental governance, which increases the short-term cost burden and is not conducive to the creation of firm value, some firms in the research sample are implementing innovative measures in environmental governance and achieving significant improvements, which may be the reason that the current enterprise environmental governance coefficient is negative but not significant. Thus, there is no discernible adverse effect on the current firm value from the entire sample of corporate environmental governance. With the exception of cash holding, all control variables have a strong correlation with firm value. The firm size (Size) coefficient is -0.672, (1% level significance), suggesting that as companies in high-polluting industries grow, their ability to adjust to changing conditions decreases, and they become more vulnerable to the "big company disease," which leads to inefficient management and a decline in firm value. Financial leverage increases firm value, as indicated by the coefficient of financial

Table 2 Descriptive statistics

Variable	N	Mean	Standard deviation	P25	Median	P75	Min	Max
Tbq	4025	1.998	1.225	1.194	1.575	2.325	0.870	7.423
Env	4025	0.529	0.972	0	0	0.928	0	6.536
Size	4025	22.461	1.298	21.555	22.250	23.274	20.130	26.314
Lev	4025	0.431	0.208	0.264	0.426	0.589	0.047	0.910
State	4025	0.484	0.499	0	0	1	0	1
Top1	4025	0.368	0.148	0.256	0.353	0.471	0.107	0.771
Grow	4025	0.126	0.303	-0.035	0.086	0.220	-0.459	1.698
Cash	4025	0.135	0.113	0.056	0.100	0.177	0.009	0.556
Age	4025	2.844	0.304	2.708	2.890	3.045	1.792	3.367

Table 3 Results of the current corporate environmental governance on the current firm value

Variable	Coefficient	t value
Env	−0.029	−1.018
Size	−0.672***	−17.043
Lev	0.519***	3.803
State	−0.646***	−4.547
Top1	−1.319***	−5.814
Grow	0.183***	4.717
Cash	0.151	0.957
Age	1.198***	4.306
Constant	13.713***	12.158
Year/Ind	Yes	
Within R^2 / F value	Within R^2=0.329 F (14, 3436)=120.49***	
F test	F (574, 3436)=9.84*** Prob > F=0.00	
Breusch-pagan test	Chi2 (1)=3023.32*** Prob > Chi2=0.00	
Hausman test	Chi2 (8)=153.41*** Prob > Chi2=0.00	

***, **, and * show significance at 1%, 5%, and 10%, respectively

leverage (Lev), which is 0.519. The significantly negative property rights (State) of state-owned holding companies indicate that their market value is lower than that of non-state-owned holding companies. Since ownership concentration (Top1) is negative, the value of the company is adversely impacted by the percentage of the largest shareholder. Firm value is positively impacted by both firm age and firm growth ability, as indicated by the significantly positive regression coefficients for both firm growth and firm age. Although positive, the coefficient of cash holding is not statistically significant.

Hypothesis 2 tests the lag effect of CEG and analyzes the relationship between CEG and company value in the future by examining the differences in the impact of CEG on firm value in different lag periods. According to the regression test of model (2) constructed above, the corporate environmental governance of the second and third lag periods can have a positive impact on firm value.

According to Table 4, the regression coefficient for corporate environmental governance started to turn positive at 0.010, or one period behind, but it is not statistically significant. The results show that CEG has a lag effect on the promotion of firm value, and that corporate environmental governance with a lag of two or more periods can positively affect firm value. The corporate environmental governance coefficients of the second and third lag periods are positive and significative at 10% and 5% level, respectively. Combined with the results of the previous current relationship test, this shows that in the short term (current period and lag period 1), corporate environmental governance will not reduce the value of the enterprise, nor bring significant benefits to the enterprise, while in the long term (lag period 2 and lag period 3), corporate environmental governance can help to enhance the future value of the the firm. Therefore, hypothesis 2 is accepted.

5.2 Robustness test

To draw reliable research conclusions, we adopt the following robustness tests to replace the measurement methods of the research variables.

Table 4 Regression results of corporate environmental governance on firm value in future periods

Variable	Env_{t-1}	Env_{t-2}	Env_{t-3}
Env_{t-j}	0.010 (0.795)	0.004* (1.783)	0.019** (2.290)
Size	−0.680*** (−14.775)	−0.698*** (−12.055)	−0.711*** (−8.960)
Lev	0.373*** (2.477)	0.413** (2.325)	0.246 (1.089)
State	−0.559*** (−3.377)	−0.538*** (−2.894)	−0.500** (−2.232)
Top1	−1.199*** (−4.652)	−1.154*** (−3.627)	−1.029** (−2.288)
Grow	0.144*** (3.431)	0.107** (2.288)	0.097* (1.783)
Cash	0.704*** (3.816)	0.939*** (4.287)	0.812*** (2.922)
Age	0.698* (1.961)	0.019 (0.039)	−1.170 (−1.592)
Constant	15.289*** (11.012)	17.685*** (9.601)	21.572*** (8.088)
Year/Ind	Yes	Yes	Yes
Within R^2	0.342	0.355	0.394
F test	9.18***	8.15***	7.03***
Breusch-pagan test	2468.89***	1769.26***	1131.64***
Hausman Chi value	92.00	69.67	49.60
P value	0.000	0.000	0.000
N	3450	2875	2300

() is t-value. ***, **, and * show significance at 1%, 5%, and 10%, respectively. Through the tests of F, BP, and Hausman, the fixed effect model is adopted. P value is that result of Hausman test

First, we swap out the measurement of corporate environmental governance. The models developed above are reexamined, and references to Li and Lu (2016) and Hu et al. (2020) are made. CEG is measured as the natural logarithm of environmental capital expenditure plus one. Table 5 presents the findings. Regarding enterprise environmental governance (Env), the retest results are essentially in line with the earlier findings when the new calculation method is used. While there is a significantly positive relationship between business environmental governance and business value in lag periods 2 and 3, there is no relationship between CEG and company value in the current period and the first lag period.

First, we swap out the measurement of firm value. Tobin's Q, which measures firm value in the main test, is computed using the ratio of the enterprise's total assets to its total market value. Tobin's Q is computed using an alternative method in the robustness test. Custodio (2014) and Yan et al. (2020) state that the formula for calculating Tobin's Q value is [total market value of a firm / (book value of total assets—net intangible assets—net goodwill)], which is the ratio of the enterprise's total market value to its tangible assets. Next, the regression test is run for models (1) and (2) once more. Table 6 presents the findings. Strong robustness is demonstrated by the alternative enterprise value measurement method's robustness test results, which are essentially consistent with the earlier findings.

6 Further analysis

The above test results show that there is a lag effect of CEG on the promotion of firm value. In the long run, CEG may have a cumulative effect on firm value in addition to a lag effect, for two main reasons. First, corporate environmental governance has a long

Table 5 Robustness test using substitution variable of corporate environmental governance

Variable	Env	Env$_{t-1}$	Env$_{t-2}$	Env$_{t-3}$
Env	−0.003 (−1.172)			
Env$_{t-j}$		0.0006 (0.416)	0.0003* (1.878)	0.002** (2.233)
Size	−0.678*** (−17.142)	−0.682*** (−14.767)	−0.702*** (−12.061)	−0.715*** (−8.979)
Lev	0.528*** (3.856)	0.377** (2.491)	0.425** (2.380)	0.267 (1.174)
State	−0.647*** (−4.543)	−0.560*** (−3.375)	−0.537*** (−2.875)	−0.502** (−2.214)
Top1	−1.313*** (−5.770)	−1.181*** (−4.565)	−1.132*** (−3.542)	−0.963** (−2.129)
Grow	0.188*** (4.829)	0.149*** (3.518)	0.117** (2.490)	0.107* (1.965)
Cash	0.150 (0.944)	0.694*** (3.752)	0.936*** (4.257)	0.836*** (3.003)
Age	1.237*** (4.434)	0.741** (2.075)	0.046 (0.093)	−1.158 (−1.569)
Constant	13.730*** (12.132)	15.203*** (10.916)	17.676*** (9.553)	21.603*** (8.061)
Year/Ind	Yes	Yes	Yes	Yes
Within R^2	0.327	0.340	0.352	0.390
F test	9.87***	9.22***	8.13***	6.98***
Breusch-pagan test	3029.51***	2479.74***	1764.31***	1121.05***
Hausman Chi value	154.90	91.36	70.07	52.45
P value	0.000	0.000	0.000	0.000
N	4025	3450	2875	2300

() is t-value. ***, **, and * show significance at 1%, 5%, and 10%, respectively. Through the tests of F, BP, and Hausman, the fixed effect model is adopted. P value is that result of Hausman test

investment cycle, so it requires continuous investment of firms to achieve a good environmental governance effect. Long-term accumulation of energy-saving and emission-reduction technology and green development results can be obtained by external stakeholders, followed by establishment of a corporate image incorporating environmental protection in the outside world, which will help to promote the transformation of corporate environmental governance costs into firm value creation. Second, Fujii et al. (2013) point out that the introduction of a cleaner production method can improve economic efficiency, but it first requires firms to learn and accumulate knowledge and experience on how to reduce environmental pollution. In many cases, enterprises are learning more effective ways to reduce pollution in their daily environmental management activities. However, firms often need to use end-of-pipe treatments to reduce pollution before they can develop sufficient capacity to apply cleaner production methods to comply with the basic requirements of environmental regulations. During this period, when firms adopt end-of-pipe treatment to reduce pollution emissions, economic benefits will generally decline temporarily, and as firms acquire relevant human resources, experience, and capabilities to introduce cleaner production methods or technologies, the capabilities and technologies of employees will gradually accumulate, enabling firms to engage in environmental governance activities more effectively. Economic performance can also be improved with the improvement of environmental performance, so that the environmental governance achievements accumulated by firms can be transformed into firm value creation (Dost et al., 2019; Remmen & Lorentzen, 2000). In addition, the research and development, manufacture, and promotion

Table 6 Robustness test using substitution variable of firm value

Variable	Env	Env$_{t-1}$	Env$_{t-2}$	Env$_{t-3}$
Env	−0.028 (−1.207)			
Env$_{t-j}$		0.012 (0.853)	0.002* (1.949)	0.017** (2.196)
Size	−0.613*** (−13.833)	−0.610*** (−11.845)	−0.645*** (−9.990)	−0.687*** (−7.835)
Lev	0.547*** (3.570)	0.410** (2.431)	0.510** (2.574)	0.358 (1.433)
State	−0.738*** (−4.622)	−0.622*** (−3.361)	−0.592*** (−2.859)	−0.535** (−2.162)
Top1	−1.602*** (−6.282)	−1.464*** (−5.076)	−1.453*** (−4.096)	−1.415*** (−2.847)
Grow	0.233*** (5.363)	0.190*** (4.031)	0.154*** (2.946)	0.133** (2.219)
Cash	0.296* (1.670)	0.284 (1.375)	0.527** (2.157)	0.464 (1.510)
Age	1.086*** (3.473)	0.443 (1.114)	−0.622 (−1.135)	−2.474 (−3.045)
Constant	13.034*** (10.279)	14.751*** (9.499)	18.689*** (9.100)	25.249*** (8.564)
Year/Ind	Yes	Yes	Yes	Yes
Within R^2	0.315	0.325	0.340	0.387
F test	10.00 ***	9.60***	8.63***	7.61***
Breusch-pagan test	3054.38***	2558.28***	1840.16***	1195.74***
Hausman Chi value	136.73	80.34	70.26	57.33
P value	0.000	0.000	0.000	0.000
N	4025	3450	2875	2300

The number in parentheses is t-value. ***, **, and * show significance at 1%, 5%, and 10%, respectively. Through the tests of F, BP, and Hausman, the fixed effect model is adopted. P value is that result of Hausman test

of green products also require sustained time investment, and then with the help of market promotion and the gradual formation of a green reputation, those green products become a way for businesses to gain a competitive advantage. Based on this previous analysis, we argue that there may be a cumulative effect of CEG on the promotion of firm value.

To test the cumulative effect of corporate environmental governance on firm value enhancement, based on the previous model (2), we construct regression model (3), (4), and (5).

Model (3) is used for the regression test of the cumulative effect of two periods of CEG, while model (4) and model (5) are used for the regression of the cumulative effect of three periods of business environmental governance and the cumulative effect of four periods of business environmental governance, respectively.

$$\begin{aligned}
\text{Tbq}_{i,t} = {} & \gamma_0 + \gamma_1\left(\text{Env}_{i,t-1} + \text{Env}_{i,t}\right) + \gamma_2\text{Size}_{i,t} + \gamma_3\text{Lev}_{i,t} + \gamma_4\text{State}_{i,t} \\
& + \gamma_5\text{Top1}_{i,t} + \gamma_6\text{Grow}_{i,t} + \gamma_7\text{Cash}_{i,t} \\
& + \gamma_8\text{Age}_{i,t} + \lambda_3\sum_{k=1}^{7}\text{Ind}_k + \eta_3\sum_{y=1}^{6}\text{Year}_y + \varepsilon_{i,t}
\end{aligned} \tag{3}$$

$$
\begin{aligned}
\text{Tbq}_{i,t} = {} & \rho_0 + \rho_1\left(\text{Env}_{i,t-2} + \text{Env}_{i,t-1} + \text{Env}_{i,t}\right) + \rho_2\text{Size}_{i,t} + \rho_3\text{Lev}_{i,t} \\
& + \rho_4\text{State}_{i,t} + \rho_5\text{Top1}_{i,t} + \rho_6\text{Grow}_{i,t} \\
& + \rho_7\text{Cash}_{i,t} + \rho_8\text{Age}_{i,t} + \lambda_4\sum_{k=1}^{7}\text{Ind}_k + \eta_4\sum_{y=1}^{6}\text{Year}_y + \varepsilon_{i,t}
\end{aligned} \tag{4}
$$

$$
\begin{aligned}
\text{Tbq}_{i,t} = {} & \mu_0 + \mu_1\left(\text{Env}_{i,t-3} + \text{Env}_{i,t-2} + \text{Env}_{i,t-1} + \text{Env}_{i,t}\right) \\
& + \mu_2\text{Size}_{i,t} + \mu_3\text{Lev}_{i,t} + \mu_4\text{State}_{i,t} + \mu_5\text{Top1}_{i,t} \\
& + \mu_6\text{Grow}_{i,t} + \mu_7\text{Cash}_{i,t} + \mu_8\text{Age}_{i,t} + \lambda_5\sum_{k=1}^{7}\text{Ind}_k \\
& + \eta_5\sum_{y=1}^{6}\text{Year}_y + \varepsilon_{i,t}
\end{aligned} \tag{5}
$$

Taking the balanced panel data of 575 listed companies of heavy-pollution industries in China for seven consecutive years from 2012 to 2018 as the research sample, the regression tests are conducted according to model 3, 4, and 5 (Table 7). The regression coefficient of the accumulated corporate environmental governance in the two periods is 0.005, but it is not statistically significant, indicating that the accumulated corporate environmental governance in the two periods neither has significant economic consequences for the firms nor does adversely affect the value of the firms. The regression coefficient of corporate environmental governance of three cumulative periods is 0.011, indicating that business environmental governance over three cumulative three periods

Table 7 Regression results of cumulative effect of corporate environmental governance on firm value

Variable	Accumulate two periods	Accumulate three periods	Accumulate four periods
Env	0.005 (1.418)	0.011* (1.778)	0.024** (2.215)
Size	−0.618*** (-13.662)	−0.698*** (−12.052)	−0.708*** (−8.926)
Lev	0.356** (2.493)	0.415** (2.335)	0.247 (1.092)
State	−0.565*** (−3.412)	−0.544*** (−2.929)	−0.503** (−2.244)
Top1	−1.185*** (−4.594)	−1.145*** (−3.597)	−1.032*** (−2.294)
Grow	0.132*** (3.385)	0.107** (2.289)	0.097* (1.785)
Cash	0.699*** (3.792)	0.943*** (4.309)	0.835 (3.008)
Age	0.682* (1.901)	0.009 (0.018)	−1.196 (−1.627)
Constant	15.349*** (11.060)	17.724*** (9.625)	21.598*** (8.094)
Year/Ind	Yes	Yes	Yes
Within R^2	0.344	0.355	0.393
F test	9.20***	8.14***	7.01***
Breusch-pagan test	2464.75***	1758.70***	1122.47***
Hausman chi value	94.77	71.97	51.07
P value	0.000	0.000	0.000
N	3450	2875	2300

The number in parentheses is *t*-value. ***, **, and * show significance at 1%, 5%, and 10%, respectively. Through the tests of *F*, BP, and Hausman, the fixed effect model is adopted. *P* value is that result of Hausman test

begins to have a cumulative promotional effect on firm value, such that the economic benefits brought by continuous investment in environmental governance are significantly greater than the cost expenditure. The cumulative coefficient of corporate environmental governance for four periods is also significantly positive, and at 0.024 is greater than the cumulative coefficient of three periods (0.011). As a result, the long run positive impact of CEG on firm value has a large cumulative effect.

7 Conclusions and implications

Based on balanced panel data of Chinese heavy-pollution companies, we empirically test the relationship between CEG and firm value from the short- and long-term perspectives, drawing the following conclusions: (1) The relationship between CEG and company value in the current period and the first lagged period is not significant. Corporate environmental governance does not achieve immediate results in terms of economic returns. In the short term, corporate environmental governance investment will neither reduce firm value nor produce significant economic benefits for the firm. (2) Corporate environmental governance in the second and third lag periods has a positive impact on the company value, which indicates that CEG has a lag effect on the promotion of firm value. In the long run, the economic benefits generated by corporate environmental governance can offset the cost and exceed expenditure, thus helping to enhance firm value. (3) The cumulative effects of the third or fourth periods of corporate environmental governance have a positive impact on firm value, and the coefficient of the cumulative effect of the fourth period of CEG is greater than the coefficient of the cumulative effect of three periods, indicating that CEG has a significant cumulative effect on the promotion of firm value, and enterprises should invest in three or more periods of environmental governance. (4) The lagged effect and cumulative effect of corporate environmental governance in the long run support Porter's theoretical hypothesis that corporate environmental governance helps to enhance firm value.

The above conclusions have the following management implications: The positive impact of CEG on firm value has a lagged and cumulative effect. Firms must correctly understand the impact of corporate environmental governance on firm value from a long-term perspective. In the short term, although corporate environmental governance does not have direct positive economic consequences for firms, it also does not significantly reduce firm value. In the long term, corporate environmental governance can have a positive impact on the promotion of firm value. Therefore, firms should not avoid or passively adopt environmental response strategies, which will lead to potential environmental risks and will not be conducive to their sustainable development. Enterprises should take green development as the premise of survival and the basis of development, engage in active strategic planning and long-term deployment of environmental governance from the perspective of long-term development, gradually introduce cleaner production methods, and adopt a series of innovative measures for environmental governance, such as turning waste into resources, so as to make sustained investments in corporate environmental governance. This can then become a source of competitive advantage for enterprises, achieving a win–win situation of environmental and economic benefits and enabling firms to achieve sustainable development. All these policy implications are important for companies to become more sustainable and not just offer greenwashing.

One of the keys to success in achieving sustainability and not just offering a misleading green image lies in the coordination and collaboration of the different agents involved at the corporate level and in applying the highest standards of transparency. Today, being a green company is an advantage over the competition. However, it is necessary to be truly green and to make short-, medium-, and long-term corporate green commitments. Simply offering a green facelift, far from reality, will end up being discovered and will damage the company's image in the long term.

With a view to future work, it would be possible to analyze through interviews with consumers and workers, whether they believe that corporate greenwashing is a reality, and to detect the main problems existing in companies. An analysis could also be carried out to differentiate by type of market, and distinguishing by time periods, to determine, for example, whether the COVID-19 pandemic, or the publication of the Sustainable Development Goals and the 2030 Agenda have considerably affected the green performance and planning of companies.

Declarations

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