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Do disclosure of ESG information policies inhibit the value of heavily polluting Enterprises?—Evidence from China

Yan Liu [a], Ya Deng [a], Yan Liu [a], Changqing Li [a], Martinson Ankrah Twumasi [a,*], Ya Cheng [a]

[a] College of Economics, Sichuan Agricultural University, Chengdu 611130, China

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ABSTRACT

Green governance and high-quality green development are crucial to the growth of enterprises; therefore, this paper examines how environmental, social, and corporate governance (ESG) disclosure policies affect the value of heavily polluting companies. The study's data is from the new version of the Governance Guidelines for Public Companies promulgated by the China Securities Regulatory Commission in 2018. Thus, the data of China's public companies from 2011 to 2021 is used for the study's analysis. The methods applied for our estimation analysis are the differences-in-differences (DID) and the mediation effect model. The findings depict that ESG information disclosure policies can significantly inhibit the corporate value of heavily polluting enterprises (HPE). Enterprise technological innovation plays a mediating effect in this mechanism; that is, after introducing the policy, it effectively alleviates the information asymmetry and promotes enterprise technological innovation, but it also damages the enterprise value. Further analysis shows that the inhibition effect of ESG information disclosure policy on the value of HPE is heterogeneous, and for non-state-owned enterprises, ESG information disclosure policies have a stronger inhibitory effect. Also, there is little difference between the central and western regions and the eastern region in terms of the inhibitory effect of ESG disclosure policies on the value of HPE. The conclusion of this paper is conducive to improving the information disclosure policy of listed companies and promoting the green development of enterprises.

1. Introduction

With the complexity and diversification of modern enterprise operations, enterprises' long-term development and value enhancement are affected by comprehensive factors such as macro policies, social responsibilities, and enterprise management. After entering a new stage of high-quality economic development, industrial structure adjustment will be comprehensively promoted. The development of new green industries has become a new goal of enterprise development. Enterprises must comprehensively pursue economic value and social responsibility for coordinated and unified development [1,2]. In recent years, listed companies have been falsified in public disclosure of environmental pollution and financial statements. The ESG concept that can integrate the three levels of environmental, social, and corporate governance proposed by investment institutions represented by Morgan Stanley Capital International (MSCI) has been widely accepted. ESG puts forward a development concept that pursues the unity of economic value and social value, which is based on how to coordinate the development of the environment, society, and corporate governance as the

* Corresponding author.
E-mail address: twuma2012@sicau.edu.cn (M. Ankrah Twumasi).

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development concept. The disclosure performance of ESG also represents the enterprises' integrated performance in market places [3,4]. Corporate ESG information disclosure more comprehensively reflects corporate value through environmental governance performance, society's sense of responsibility, and enterprise management. It provides subsequent corporate investors with public information disclosure that aligns with high-quality social and economic development [5,6]. Also, improved ESG performance is conducive to enterprises' high-quality growth [7,8].

In 2018, the new version of the Code of Governance for Listed Companies of the China Securities Regulatory Commission incorporated environmental and social responsibility into the framework of information disclosure of listed companies. They changed the standards of corporate governance information disclosure to make it more stringent. Since then, the ESG information disclosure framework of listed companies has been formed. The implementation of the ESG information disclosure policy, as a corporate-related institutional change, will bring a lot of changes to the operation of listed companies, especially those related to heavy pollution, which need to optimize and innovate their industrial structure in response to environmental information disclosure [9]. The investment will also impact the enterprise's related financing and value [10]. Hence, exploring further how corporate ESG information disclosure policies affect corporate value in 2018 is necessary.

As the concept of comprehensive and coordinated development of ESG is gradually embedded in enterprises' development strategy and business process, ESG has attracted much attention and discussion by domestic and foreign scholars. Research on ESG information disclosure mainly focuses on the relationship between corporate ESG performance and corporate value performance but has not reached a consistent conclusion [11,12] (Table 1). Most scholars believe corporate stakeholders and investors will enhance corporate value by comprehensively analyzing corporate development potential and increasing trust in corporate investment and financing through ESG disclosure [13]. Zhou et al. [14] pointed out that enterprises often improve their corporate image through ESG public information, form a better cognitive system with stakeholders, and ultimately achieve the purpose of enhancing corporate value. Based on a sample of major market indices in the United States, Japan and Europe, Rio Murata [15] pointed out that despite regional differences, ESG disclosure reduces the risk of future stock price collapses. Reber's [16] study in the United States further proved that voluntary disclosure of ESG information reduces stock characteristics risk and downside tail risk during Initial public offerings (IPO). Also, the results found that ESG information disclosure can be conducive to establishing a good corporate reputation for companies after listing. Limkriangkrai [17] found that ESG investment methods can reduce corporate risks and promote corporate performance by investigating the impact of environmental, social, corporate governance, and comprehensive ESG ratings of Australian listed companies on corporate financing decisions. By analyzing the data of listed companies in China from 2010 to 2019. Yu [18] found that there was a significant positive correlation between ESG performance and enterprise value. Pulino [19] conducted empirical research from both capital structure and operational aspects of business activities, showing that ESG information disclosure significantly positively affects the company's performance, that is, consumers do pay attention to and recognize the social value of corporate ESG, and corporate managers are more willing to disclose this information to attract more customers.

On the other hand, few scholars believe that in response to ESG disclosure policies, some heavily polluting companies excessively pursue social responsibility performance, which reduces their competitive advantage in the industry. Sassen et al. studied listed companies in Europe and found that taking on too much social responsibility can reduce corporate value [20]. The significance of how ESG impacts the value of HPE remains to be studied [21].

Since ESG information disclosure serves as a strong policy concept for long-term enterprise development and has a remarkable influence on the environmental information disclosure of heavily polluting companies, it is essential to examine the association between the two elements. The implementation of ESG information disclosure policy is important in developing HPE since it aggravates the improvement of the input and output of technological innovation for environmental regulation. It also improves the financing capacity of enterprise operation and development. Research shows that the debt financing ability of serious enterprises causing pollution can improve the ability of these enterprises to face changes in policies and the external environment, thus, enhancing the overall enterprise value by improving R&D and operational efficiency [22,23]. Technological innovation is the most critical means for heavy-polluting enterprises to enhance their comprehensive development level, the pursuit of technological and industrial structure innovation by enterprises can improve their competitive advantages in the industry and help reduce their financing costs [24].

Compared with foreign studies, it is not difficult to see that the time for public information disclosure of listed companies in China is

Table 1
Literature review.

Author's Information	Variable Name	Variable Relation
Bo,W.; Maojia,Y [13]	Financing constraint, Media	Investors will comprehensively analyze the development potential of enterprises through ESG disclosure, increase their trust in enterprise investment and financing, and thus enhance enterprise value.
Zhou,G.; Liu,L [14]	Financial Performance	The improvement of ESG performance is conducive to the improvement of the company's operating ability, and thus increases the company's market value.
Murata,R.; Hamori,S [15]	SIZE, ROAs	ESG disclosure policies reduce the risk of future share price crashes
Beat,R.; Agnes,G [16]	Sales, Net income	Voluntary ESG disclosure reduces idiosyncratic volatility and downside tail risk.
Limkriangkrai,M.; Koh, S. K [17]	Size,Lev,Roa	ESG investment can reduce corporate risk and improve corporate performance
Xiaoling,Y.; Kaitian,X [18]	Roa,Mb	By using Tobin's Q, return on assets (ROA), and price-to-book ratio (MB) as proxy variables of firm value, the study finds that ESG comprehensive performance has a significant positive correlation with firm value.
Carnini,P,S.; Ciaburri,M [19]	EBIT,ROA	Conducted empirical research from both capital structure and operational aspects of business activities, showing that ESG information disclosure significantly positively affects the company's performance.
Sassen,R.; Hinze,A.K [20]	Roa,Lev,Mtb	The study found that social performance had a significant negative impact on all three risk measures.

relatively short. Few Chinese scholars have studied the how ESG information disclosure policies impact corporate value; however, there are still shortcomings in the research on the mediating effect of corporate technological innovation in ESG information disclosure. First, present researches have paid more attention to the impact of ESG ratings on corporate value while ignoring the overall impact on corporate value before and after ESG-related policies. Second, in the relationship between ESG information disclosure and corporate value, existing studies have focused too much on corporate performance and seldom considered the relationship between ESG information disclosure policy and the system itself on corporate behavior and value. Third, the relationship between debt technological innovation of HPE on the value of enterprises is not yet clear at present, and the specific effect needs to be studied.

Based on A-share heavy polluting enterprises in China data from 2011 to 2021, this paper studies and discusses how ESG information disclosure policies influence the value of HPE. We also examine the mediating effect of technological innovation in the ESG information disclosure policies and the value of heavily polluting enterprise relationships. We further analyze the moderating effect of enterprise entity heterogeneity on the above relationship. Compared with existing research, this paper makes up for the impact of enterprises' responses to mandatory ESG information disclosure in 2018 on their corporate value in ESG-related research. The following are the innovations of this paper. First, it analyzes and probes into the impact of ESG information disclosure policy on corporate value before and after the key policy node in 2018, and establishes empirical evidence for the actual China's implementation effect of ESG disclosure policy and related empirical research, first in its kind. Second, based on the arrival of the current scientific and technological era, we explore the internal mediation mechanism and correlation effect of corporate technological innovation in the ESG information disclosure policies and corporate value linkage. Third, grouping the heavily polluting companies' ESG ratings, ownership nature, and regional differences and further discussing the relationship between ESG disclosure policies and corporate value will help identify differences in policy effects and make research conclusions more valuable for reference. Thus, improving the impact of ESG information disclosure policies.

2. Proposed hypothesis

2.1. Information disclosure and enterprise value

The implementation of ESG information disclosure policy will promote the information disclosure of listed companies. ESG information disclosure includes three aspects: environment, society, and corporate governance. Scholar research on the overall ESG information disclosure in corporate governance literature is less, but scholars have different views. Supporters believe that when an enterprise actively discloses ESG information, it can gain more attention and support and accumulate reputation, improving the willingness to consume and invest [25]. Therefore, good ESG information disclosure will improve enterprise value [26,27]. Opponents believe that in the short term, the disclosure of ESG information means enterprises will invest more governance funds in environmental, social responsibility, and corporate governance. They believed that these investments would cause an increment in the enterprises' operating costs and reduce corporate interests; thus, reducing corporate value [28]. Therefore, the hypotheses for the study is as follows.

H1a. ESG disclosure policies promote the corporate value of heavily polluting companies.

H1b. ESG disclosure policies will inhibit the corporate value of heavily polluting companies.

2.2. Technological innovation

Technological innovation is of great significance to the development of modern enterprises, and innovation-driven development has become a social consensus, especially in terms of improving the level of development of manufacturing enterprises [29]. In the related research on how policies affect HPE, scholars have paid great attention to the Porter hypothesis. The Porter hypothesis states that environmental regulation will enhance the enterprises' innovation strength, thereby increasing productivity to offset the costs caused by environmental protection and improve corporate profitability [30]. However, in actual research, scholars hold different opinion on the association between information disclosure and technological innovation. Supporters believe that information disclosure is important for external investors and stakeholders to understand enterprises' internal investment and financing. When the policy requires enterprises to disclose information, it will enhance the performance sensitivity of managers' compensation and encourage them to invest in innovation [31,32]. In addition, information disclosure can alleviate information asymmetry and promote technological innovation by reducing enterprise research and development (R&D) risks and reduce information costs [33,34]. Opponents believe that in a short period of time, HPE implementing information disclosure tend to increase environmental protection investment and governance costs [35]. Since the environmental protection status of HPE is worse than that of non-HPE, enterprises will invest in pollution control and emission reduction; therefore, the information disclosure of enterprises to fulfill social responsibilities will cause a crowding effect on new R&D investment. However, the policy encourages funds to flow to the emerging sectors with advanced technologies, which may force HPE to carry out technological innovation to obtain investment funds.

Enterprise technological innovation has a multi-faceted impact on enterprise value; however, the benefits brought by innovation output and high R&D investment may offset each other [36,37]. Long cycle is the characteristic of enterprise technological innovation. High risks, and high uncertainty of results, and most applied patents will not bring immediate benefits. However, the capital invested by enterprises in technological innovation will bring a lot of costs, which will occupy the capital of enterprises' physical investment, affecting the value of enterprises (see Fig. 1). Therefore, this paper proposes the following assumptions.

H2. ESG disclosure policies will inhibit corporate value by enhancing technological innovation in heavily polluting companies.

3. Data and methodology

3.1. Data

This paper selects Chinese listed companies from 2011 to 2021 as the initial sample, depending on the Classified Management List of Listed Companies' Environmental Protection Verification Industries published by the former Ministry of Environmental Protection in 2008, combined with the definition of heavily polluting industries in the Guidelines for Environmental Information Disclosure of Listed Companies in 2010, the industries in which sample companies are divided into heavily polluting industries and other industries. Among them, the heavily polluting industries include 16 industries, such as thermal power, steel, and coal, and the remaining industries are divided into other industries, and the samples are screened according to the following criteria: (1) Exclude ST companies; (2) Exclude companies in the financial industry; (3) Exclude samples with missing data. To avoid the influence of extreme values, this paper conducts Winsorise treatment of 1 % up and down for all continuous variables and finally obtains a total of 1964 listed companies, of which 988 are companies in heavy pollution industries as the experimental group, and 976 companies in other industries are used as the control group. The financial data, R&D investment, and patent data are all from the Wind database, and the ESG rating data is from the Huazheng Rating System.

3.2. Variable definition

Tobin's Q is chosen as the explained variable to measure the value of listed companies, and the ratio of total assets is measured by the sum of the company's equity market value and net debt market value. Tobin's Q value can consider the market characteristics and financial characteristics of listed companies at the same time. The organic combination of entity financial data has great advantages and wide application in measuring the long-term value of enterprises.

The paper's independent variables is Treatedi Timeit, which represents the "policy" treatment variable (i.e., the double difference term) in the DID model. Among them, Treatedi is the dummy variable of the treatment group and the control group. If the enterprise i belongs to the heavily polluted enterprise, it will enter the treatment group and take the value of 1; otherwise, take the value of 0. This paper takes the new version of the Governance Guidelines for Listed Companies promulgated by the China Securities Regulatory Commission in 2018 as the policy. Although the Governance Guidelines for Listed Companies is a policy in 2018, its official implementation time is 2019, and considering the time lag of policy effects, the year of implementation of this policy is 2019. Timeit is the policy time dummy variable, which takes the value of 1 for 2019 and later periods, and 0 otherwise.

There are two main intermediary variables in this paper. It is technological innovation. Generally speaking, the R&D innovation of an enterprise includes two aspects (i.e., input and output). R&D investment, as the initial investment of resources, is affected by risks such as high failure rate and great uncertainty in the R&D process. Therefore, innovation output can more intuitively and effectively reflect the technological innovation level of an enterprise. This paper refers to the practice of Bo [36], and uses the number of invention patent authorizations (patent) to measure enterprises' technological innovation level.

Many factors affect enterprise value. This paper refers to the research of Ma [38], and adds other control variables that may affect

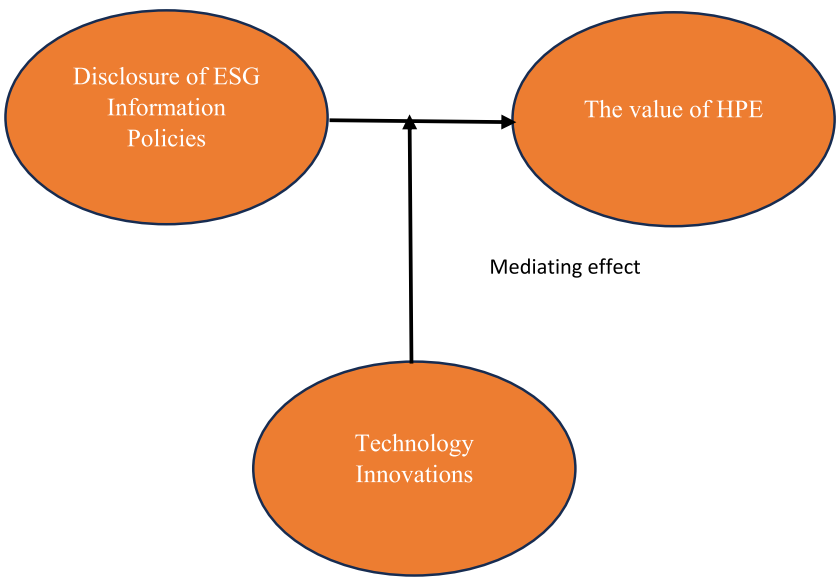

Fig. 1. Flow chart.

enterprise value, including enterprise scale, debt level, growth, total asset return rate, and equity concentration. Due to the large difference between the data on enterprise scale and debt level, the logarithm is used for regression. The variable table is shown in Table 2.

3.3. Models for empirical analysis

3.3.1. DID model and PSM-DID model

In 2018, the China Securities Regulatory Commission issued a new version of the Governance Guidelines for Listed Companies. Compared with the 2012 version, the disclosure of social responsibility and environmental information was added to the disclosure information of listed companies for the first time in the 2018 version, establishing the information disclosure framework of ESG, so it can be regarded as an important policy of ESG disclosure policy. The research on ESG disclosure will be in-depth step by step, so this paper sets up the following DID benchmark.

$$Tobinq_{it}=\alpha+\beta Treated_i * Time_t+\gamma X_{it}+Company_i+Year_t+\varepsilon_{it} \quad (1)$$

regression model to study the impact of this policy (Equation (1)):

Among them,

α = constant term, and β = coefficient of multiplication term. If the result is significantly negative, it can be proved that the ESG disclosure policy will reduce the enterprise value of HPE. In addition, considering the characteristics of corporate financial structure and corporate governance structure, five control variables X are added, γ is the coefficient of control variable; Company and Yeart represent the fixed effects of enterprise and time respectively; is the residual term. The subscripts, i = ith enterprise and t = the year of the enterprise.

The important principle of using the DID method is making the experimental and control groups obtain a common trend assumption, that is, if there is no policy implementation in 2018, the enterprise value of heavily polluting and non-heavy polluting enterprises will not change significantly over time. However, this paper is not very strict in terms of common trends, so this paper refers to the practice of Ruiming and Renjie [39]in the robustness test and uses the propensity score matching-differences in differences (PSM-DID) method to solve this problem. Propensity score matching (PSM) is also called propensity score matching. Its basic idea is to find company j in a non-heavy polluting enterprise so that its observable variables are as similar as possible to that of company i in a heavily polluting enterprise, Xi ≈ Xj. When the individual characteristics between the two were only affected by the implementation of the 2018 ESG Disclosure Policy, they could be compared. Matching estimators can help address the issue of the assumption that the experimental and control groups in the DID not fully share a common trend assumption before being affected by the 2018 ESG disclosure policy. Since HPE are more affected by ESG information disclosure policies, this paper uses HPE as the experimental group and non-HPE as the control group, and draws on the theories of Zhongqi [40] and others. The situation will be difficult to satisfy that the products of the HPE and the non-heavy polluting enterprises are not entirely homogeneous, but if there is a situation where the products can be completely replaced or otherwise contradict the subsequent theoretical model, the policy effect will not be identified in the test; on the contrary, If the policy effect is significant, it can indicate that the model we set and the related conclusions are reasonable.

3.3.2. Mediating effect model

Since this paper explores the mediating effect of ESG disclosure policies on the value of heavily polluting companies, this paper

Table 2
Variable definition.

Variable Types	Variable Name	Variable Symbol	Variable Definitions
Explained variable	Corporation value	Tobinq	(Circulation market value + Net assets attributable to non-tradable shares + Book value of liabilities)/Total assets at the end of the period
Explanatory variable	Policy release	Time	The 2018 Green Investment Guidelines (for Trial Implementation) shall be taken as 0 before the release and 1 after the release.
	Whether heavy polluting enterprises	Treated	Enterprises that are HPE take 1, and non-heavy polluting enterprises take 0
Mediating variable	Technological innovation	Patent	Add 1 to the sum of patents and take the logarithm
Control variable	Year	Year	Yearly dummy variable
	Company	Company	Company dummy variable
	Liabilities level	LEVt	(Total liability/Total assets) × Natural logarithm of 100
	Enterprise size	Size	Natural logarithm of total assets at the end of the year
	Profit margin on total assets	Roa	(Net profit/Total assets at the end of the period) × 100
	Growth	Growth	Growth rate of total assets relative to the beginning of the year
	Ownership concentration	Top1	The shareholding ratio of the largest shareholder × 100
	Property right character	SOE	Dummy variable, take 1 for state-owned property and 0 for non-state-owned property
	Regional differences	Region	Dummy variable, 1 for the eastern region and 0 for the central and western regions
	ESG rating	ESG	Dummy variable, 1 for ratings higher than the median, 0 for ratings lower than the median

refers to Zhonglin [41] Mediating Effect Analysis: Method and Model Development, and constructs the following mediation effect model (Equations (2)–(4)):

$$Tobinq_{it}=\alpha_1+\beta_1 Treated_i * Time_t+\gamma_1 X_{it}+Company_i+Year_t+\varepsilon_{it} \quad (2)$$

$$Mediation_{it}=\alpha_2+\beta_2 Treated_i * Time_t+\gamma_2 X_{it}+Company_i+Year_t+\varepsilon_{it} \quad (3)$$

$$Tobinq_{it}=\alpha_3+\beta_3 Treated_i * Time_t+\gamma_3 X_{it}+\theta Mediation_{it}+Company_i+Year_t+\varepsilon_{it} \quad (4)$$

Among them, α1, α2 and α3 are their constant terms, and β1, β2, and β3 are the multiplication items Treated* Time coefficients, which can well reflect the impact of the ESG disclosure policy in 2018 on the explained variables. In addition, X represents the characteristics of the company's financial structure and corporate governance structure, adding 5 control variables such as company scale, debt level, growth, total asset profitability, and equity concentration, and γ equals the coefficient of control variables. θ equal coefficient after adding the mediator variable as the control variable, Companyi, and Yeart represent the firm and time-fixed effects, respectively; is the residual term. The subscripts, i = ith enterprise and t = the year of the enterprise.

The origin for judging the mediating variable significant level is: first, test the coefficient β1 significant level in formula (1). If β1 is significant, judging the next step becomes appropriate; otherwise, the mediating effect becomes unnecessary; second, test formula (2) whether the coefficient β2 and the significance of θ in formula (3), if both are significant, it is appropriate to accept that the mediation effect of the Mediation variable is significant, and if at the same time, β3 is insignificant or its estimated value comes out significant but smaller than β1, then the variable for mediation can be considered a strong intermediary object. Third, if at least one of the coefficients β2 and θ is insignificant, a Bootstrap test become necessary in determining whether there is a mediating effect on the mediation variable. If the 95 % confidence interval of the test does not include 0, there is a mediating effect, and if 0 is included, the mediating effect does not exist. Fourth, if the Bootstrap test passes, it is necessary to check whether β2θ and β3 have the same sign. If the sign is the same, there is a partial mediation effect, and the different sign is a masking effect. Finally, the proportion of the mediating effect needs to be disclosed. |β2θ/α1| is the proportion of the mediation effect to the total effect, indicating the degree of influence of the mediation effect in the entire regression.

4. Results and discussions

4.1. Descriptive statistical analysis

The descriptive statistical analysis of each study variable is shown in Table 3, in addition to control variables, core explanatory variables, and explained variables, this paper also controls the company and annual effects. The standard deviation is 8.45 and the max—min difference is 75.10, indicating that the company has differences in organizational structure and operation mode. A patent is a big difference in technological innovation, and different companies vary greatly in R&D investment in new technologies, therefore, the standard deviation of this paper is 1.776 after data processing, which is kept at a relatively stable level. The standard deviation of the company scale is 2.668, and the mean is 26.5, indicating that the difference in the total assets of the selected companies is not obvious, which will not become the determinant of valuation fluctuation and also ensures the objectivity of the model. The standard deviation of the debt level of the selected company is 0.584, and the max—min difference is 3.29, indicating that the capital structure of the selected company is different, which will affect the company's capital cost and financial risk.

4.2. Information disclosure and enterprise value

To examine the impact, the 2019 policy had on the corporate value of heavily polluting firms, this paper controls fixed effects by year, individual, and industry. The results of column (1) in Table 4 are obtained through testing, and it is found from the cross-multiplication term in (1) that at the significant level of 1 %, the coefficient is −0.262, which can conclude that ESG disclosure policies will inhibit the increase in the value of heavy polluting enterprises compared with non-heavy polluting enterprises, assuming that H1b is verified and the hypothesis is valid. The reason is that after the policy of the China Securities Regulatory Commission is

Table 3
Statistical description.

Variables	Sample size	Mean value	S.D	Min value	Max value
Tobinq	21604	1.916	2.343	0.0678	15.43
Time	21604	0.500	0.500	0	1
Treated	21604	0.347	0.476	0	1
Lev	21604	3.719	0.584	1.249	4.539
Size	21604	22.23	2.668	0	26.50
Roa	21604	3.186	6.060	−26.05	19.30
Growth	21604	19.28	56.29	−84.18	404.7
Top1	21604	34.35	15.09	8.450	75.10
Patent	21604	2.514	1.776	0	6.878

S.D = Satndard Deviation.

Table 4
Regression result.

variable	(1)	(2)	(3)
	Tobinq	Patent	Tobinq
Treated × Time	−0.262***	0.672***	−0.234***
	(-6.393)	(16.219)	(-4.450)
Patent			−0.042*
			(-1.852)
Lev	−0.726***	0.274***	−0.715***
	(-22.412)	(7.036)	(-6.872)
Size	−0.257***	0.082***	−0.254***
	(-44.166)	(9.443)	(-10.497)
Roa	0.036***	−0.001	0.036***
	(15.567)	(-0.744)	(7.555)
Growth	0.002***	0.000**	0.002***
	(7.593)	(2.099)	(2.936)
Top1	0.001	−0.016***	0.000
	(0.529)	(-7.332)	(0.080)
Cons	10.179***	0.167	10.186***
	(58.652)	(0.674)	(16.191)
The Fixed Effects of Year/Individual/Industry	*Control*	*Control*	*Control*
N	21,604	21,604	21,604
R^2	0.202	0.124	0.202
F	827.3	110.9	67.43

Standard errors in parentheses * p < 0.1, **p < 0.05, ***p < 0.01.

implemented in 2018, heavy-polluting enterprises will tend to pay attention to their environmental performance and invest more governance funds in ESG. As a result, their operating costs will increase, and environmental performance is negatively correlated with financial performance [42]. Finally, the rise of enterprise value is inhibited.

4.3. The mediating effect of technological innovation

This section examines the mediating effect of technological innovation. Consistent with the test for the mediating effect of debt financing, Column (1) of Table 3 shows the test for Model (1), where the regression results are significant at the 1 % confidence level. After further testing, Model (2) and Model (3) are demonstrated in columns (2) and (3) of Table 3 through regression test results. The results show that β2 is 0.672, which is significant at the 1 % significance level, θis −0.042, which is significant at the 10 % level, so the next step can be judged. Further examination found that β2θ is −0.028224 and β3 is −0.234, both of which are the same number, so the technological innovation test is a partial intermediary effect. Among them, the intermediary effect β2θ is −0.028224, the total effect is −0.262, and the proportion of the intermediary effect in the total effect is 10.77 %, indicating that 10.77 % of the inhibition effect of ESG disclosure policies on the value of HPE in 2018 is due to the intermediary effect of technological innovation. Thus, the path of ESG disclosure policy affecting the enterprise value of HPE through technological innovation (i.e., H2) is established. In other words, after introducing the information disclosure policy, enterprises actively disclose information, alleviate information asymmetry, and promote enterprise technological innovation [43]. However, enterprise technological innovation means the climbing cost of enterprises and the risk of being underestimated by the market [44], and crowds out the investment of enterprise entities, thereby damaging the value of enterprises.

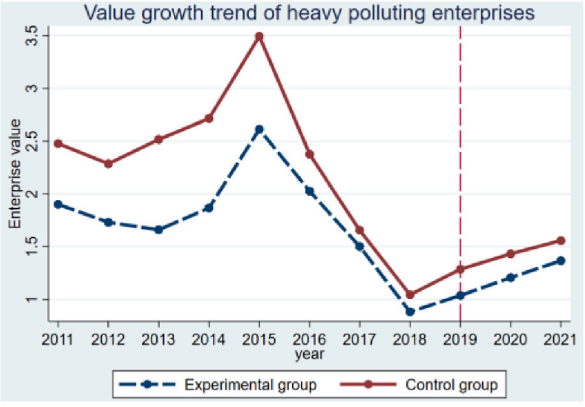

Fig. 2. Time trend test chart.

4.4. Robustness test

Before using the DID method, it is essential to perform a common supporting hypothesis test on the model to check whether significant differences between the experimental and control groups exist. Fig. 2 is a time trend chart, which shows that the changes in the experimental group and control group before the implementation of the policy in 2019 are consistent, and it can be preliminarily judged that the time trend between the two groups before the policy implementation year is basically satisfied.

This paper refers to the practice of Hu and Ding [45] to conduct a placebo test in advance of the event. Assuming that the ESG disclosure policy is advanced to 2013, the value of 2011 and 2012 is assigned to 0, and the value of subsequent years is assigned to 1. Through regression, the result is Column (1) of Table 4. As can be seen from the table that the DID cross term at this time is not significant and the exogenous time of ESG disclosure in 2013 constructed in this paper did not occur. Then, it can be seen that the enterprise value of HPE is suppressed by the ESG disclosure policy, rather than other time effects, therefore, it verifies that the regression results are robust.

At the same time, the practice of Mao et al. [46] was drawn on to conduct a placebo test by randomly assigning treatment group cities: Enterprises were randomly selected 500 times to construct the sham treatment group, and 500 regression coefficients and their P values were obtained (Fig. 3). The results are shown in the figure below, the coefficients are concentrated around 0 and follow a normal distribution, and most of the regression results are insignificant. It shows that the benchmark regression coefficient is located at a high position in the false retrospective coefficient distribution, indicating that it is a small probability event in the enterprise placebo test, that is, the benchmark regression results are not seriously disturbed by unobservable conditions.

Referring to Shi et al. [47], this paper changes the time width of the sample to identify the sensitivity of policy changes. The specific method of this paper is to narrow the time width of the sample, and reduce the original 2011–2021 data to 2018–2019 data, and the regression results are located in Column (2) of Table 5. The results show that the cross-multiplication term is still significantly negative, which is consistent with the regression results of this paper. It can be seen that the estimation results of this paper are robust.

In this paper, the propensity score matching method is used to treat the experimental and control groups, so there is no huge difference between the experimental and control groups over time before the policy implementation in 2019. The nuclear matching method is carried out to determine the weight. The comparison chart of the gap between heavy polluting enterprises and non-heavy polluting enterprises after matching and before matching is shown in Fig. 4. When the left side of Fig. 4 is not matched, it can be seen that the mean values of the experimental and the control groups do not completely coincide at this time. There is still a certain difference between the fluctuations of the two groups. The comparison chart of the fluctuations of the unexperimented group and the control group after matching on the right side of Fig. 4 shows that the fluctuations between the two have completely coincided and there is no significant difference. From this, we can conclude that there is no significant difference between the experimental and control groups after the propensity score matching, and the next step of regression can be carried out. The regression results are in Table 5 (column (3)). The result depicts that the regression is still significant and negative at the 1 % level, an indication that the regression is robust.

4.5. Analysis of heterogeneity

4.5.1. Heterogeneity analysis of ESG rating performance

In recent years, more and more rating agencies have comprehensively scored the ESG performance of listed companies, among which the rating system of Huazheng is the most widely used. According to the Huazheng ESG rating system, the enterprises are grouped into groups, and the Huazheng ESG Rating gives the enterprises a nine-level score of "C-AAA". assigning C to 1 point, CC to 2 points, and so on up to 9 points given by AAA. The scores of each company from 2011 to 2021 are then added together, the score greater than 50 is considered a group with a high ESG rating, and the score less than or equal to 50 is a group with a low ESG rating. Regressed on them respectively, the results are shown in Table 6. Regardless of ESG performance, ESG disclosure policies have a

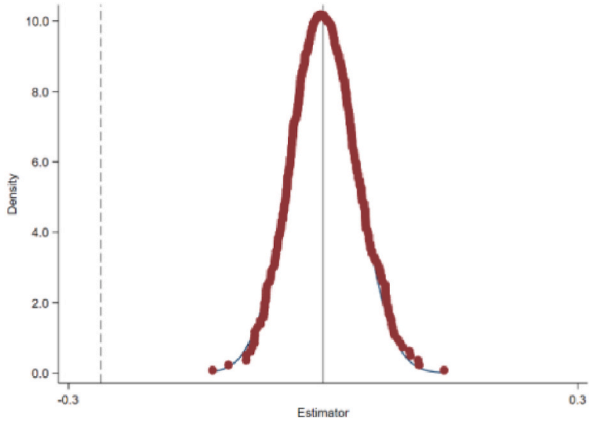

Fig. 3. Kernel density distribution and p-value plot of 500 coefficients.

Table 5
Robustness test regression.

Variable	(1)	(2)	(3)
	Tobinq	Tobinq	Tobinq
Treated × *Time*	−0.044	−0.093***	−0.283***
	(-0.887)	(-3.292)	(-5.406)
Lev	−0.674***	−0.550***	−0.702***
	(-11.949)	(-3.755)	(-4.928)
Size	−0.272***	−0.450***	−0.253***
	(-18.608)	(-3.576)	(-7.548)
Roa	0.038***	0.002	0.035***
	(10.478)	(0.790)	(5.453)
Growth	0.001	−0.000	0.001*
	(1.360)	(-0.170)	(1.823)
Top1	−0.004*	0.006	−0.002
	(-1.726)	(0.642)	(-0.523)
Cons	10.463***	13.298***	10.121***
	(28.552)	(4.682)	(12.086)
The Fixed Effects of Year/Individual/Industry	*Control*	*Control*	*Control*
N	21,604	3928	15,862
R^2	0.645	0.767	0.196
F	159.5	10.31	50.15

Standard errors in parentheses * p < 0.1, **p < 0.05, ***p < 0.01.

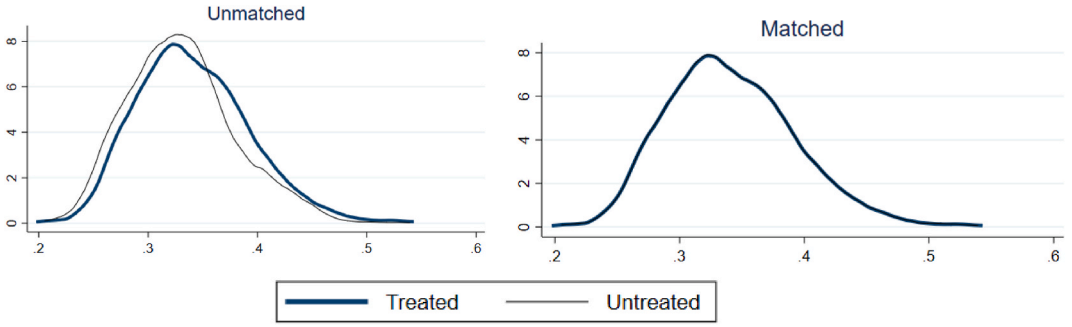

Fig. 4. Comparison of experimental group and control group before and after PSM matching.

Table 6
Heterogeneity analysis.

Variable	High ESG	Low ESG	State-owned enterprises	Non-state-owned enterprises	Eastern	Midwest
	(1)	(2)	(3)	(4)	(5)	(6)
Treated × *Time*	−0.134***	−0.888***	−0.157**	−0.299***	−0.251***	−0.266***
	(-2.719)	(-2.614)	(-2.300)	(-3.768)	(-3.991)	(-3.220)
Lev	−0.278***	−1.694***	−0.516***	−0.752***	−0.687***	−0.859***
	(-3.329)	(-6.134)	(-3.384)	(-6.269)	(-5.780)	(-4.041)
Size	−0.320***	−0.166***	−0.270***	−0.247***	−0.245***	−0.315***
	(-5.089)	(-5.315)	(-3.533)	(-9.732)	(-9.297)	(-5.399)
Roa	0.026***	0.104***	0.011*	0.045***	0.041***	0.019*
	(6.584)	(5.179)	(1.910)	(7.446)	(7.631)	(1.955)
Growth	0.002***	0.001	0.001	0.002***	0.002**	0.002*
	(4.738)	(0.461)	(1.011)	(2.798)	(2.411)	(1.732)
Topl	−0.004	0.059***	−0.006*	0.002	0.003	−0.007
	(-1.510)	(3.224)	(-1.868)	(0.499)	(0.849)	(-1.001)
Cons	9.944***	10.673***	9.705***	10.177***	9.680***	12.231***
	(7.503)	(8.526)	(5.819)	(14.587)	(13.776)	(8.873)
The Fixed Effects of Year/Individual/Industry	*Control*	*Control*	*Control*	*Control*	*Control*	*Control*
N	19,294	2310	8668	12,936	16,335	5269
R^2	0.096	0.397	0.085	0.226	0.200	0.216
F	50.86	44.05	13.62	68.25	61.14	21.19

Standard errors in parentheses * p < 0.1, **p < 0.05, ***p < 0.01.

significant negative correlation with the value of heavily polluting firms. The gap between the two groups of high and low ratings is large, and policies than companies with low ratings still less restrain companies with higher ESG ratings. Compared to enterprises with poor ESG performance, the reason is that companies with good ESG performance will give investors more confidence [48], heavy polluters with good performance will disclose information more comprehensively, so that investors have a better impression when investing, so its inhibition effect is not so strong.

4.5.2. Heterogeneity analysis of property right character

Considering the institutional context in China, there is some unequal competition between State-owned Enterprises and non-state-owned Enterprises, state-owned enterprises and non-state-owned enterprises have certain differences in social responsibility and environmental disclosure [49]. The form of corporate ownership may have different effects on the information disclosure and corporate value linkage. Based on this, the study divides the sample enterprises into two sub-samples: state-owned enterprise (SOE) and non-SOE, and conducts empirical analysis on the two samples respectively. The results are shown in Table 6. In general, the coefficient of the difference-in-difference term of the two sets of results is negative, but it is significantly higher in the non-SOE sample than in the SOE sample, indicating that the policy inhibition effect on non-SOE is more obvious. The reason is that the government has strong credibility as the actual controller of state-owned enterprises. For a long time, state-owned enterprises have also paid more attention to fulfilling social responsibilities and paying more attention to the concept of green development [50]. Compared with SOE, ESG disclosure policies put more pressure on green innovation and corporate financing for non-SOE, resulting in a decline in enterprise value.

4.5.3. Geographical heterogeneity analysis

China has a vast territory, different regions of the resource conditions vary greatly, and regional development is not balanced. Compared with the central and western regions, the economic development level and financial market environment in the eastern region are relatively better. In order to further study the impact of corporate regional heterogeneity on the relationship between ESG disclosure policies and corporate value, this paper, according to the province where the company is registered, separately from the eastern central and western sub-sample regions to study the impact of companies in regions with different levels of economic development on the two Differences in the impact of relationships. As shown in columns (5) and (6) of Table 6, both groups' coefficients of the double difference term were significantly negative in the samples from the Eastern and Midwestern regions. In the eastern region, compared with other firms, the firm value of heavily polluting firms is negatively affected by ESG policies. The reason is that after the launch of the ESG disclosure policy, under the conditions of sufficient economic development in the eastern region, the government and enterprises pursue higher quality and greener development standards, and what they pursue is not only the improvement of enterprise value [51]. Instead, it pays more attention to environmental pollution control and green technology innovation while developing, so policies will restrict enterprises because they invest more in environmental governance and R&D expenditures. Due to the relatively slow economic development in the central and western regions, after the information disclosure, the information asymmetry between investors and enterprises is reduced, and investors' expectations of the company's situation are not good, which reduces investor confidence, so compared with other enterprises, ESG policies will more inhibit the corporate value of HPE.

5. Conclusions and policy recommendations

On account of the initial sample of listed companies from 2011 to 2021, this paper extracts 988 HPE as the experimental group sample and empirically tests how ESG disclosure policy affect the value of HPE.

Research findings.

a) ESG disclosure policy has a considerable inhibitory impact on the enterprise value of HPE.
b) This paper also analyzes the mediating effect of its influencing mechanism. It is found that ESG disclosure policy significantly reduces the value of HPE through the mediating variable of technological innovation.
c) This paper also analyzes the three aspects of ESG rating, regional differences and the enterprise property rights nature. It is revealed that policies more inhibit the value of HPE with bad ESG performance. Policies other than that of non-state-owned enterprises do not significantly suppress the value of state-owned enterprises. The restraining effect of HPE in the central and western regions and the eastern region is not much different.

Based on the research conclusions, the policy recommendations come up with in this paper are as follows. Firstly, from the government's point of view. The government should continue to improve the ESG disclosure policy to avoid the problems of non-disclosure and incomplete disclosure by enterprises. The study estimates that the disclosure policy of ESG negatively impacts the value of HPE. Therefore, the government plays an indispensable role. The government can provide certification for voluntary disclosure enterprises through policy innovation to show the government's support for disclosure. Improving market participants' recognition of the enterprise can optimize the external relationship of the enterprise to reduce the operating cost. At the same time, it is possible to increase investment in technological innovation of enterprises and reduce the crowding out effect of enterprise pollution control on HPE. In addition, the government should also establish a more complete and scientific information disclosure system, give full play to the role of "leader", and gradually transform enterprises' voluntary ESG disclosure into compulsory ESG disclosure [52]. Secondly, from the perspective of HPE, HPE should actively disclose ESG information, reduce information asymmetry with investors,

improve the environmental protection status of enterprises, and enable enterprises to develop green or high-quality. HPE should focus on the social responsibility of enterprises, do not care about the short-term negative impact of ESG disclosure on enterprise value and reduce the cost of ESG disclosure. These companies should concentrate on the role of ESG in communicating with external stakeholders. Adequate ESG disclosure demonstrates corporate social responsibility, improves their image in policymakers, rating agencies and investors' minds, and reduces communication costs. At the same time, HPE should take a long-term perspective and keep their social responsibilities in mind.

Here are some limitations of the study. First, we focus on the effect of ESG disclosure policies on Enterprises alone; however, these policies go a long way to impact households. Thus, forthcoming studies can examine the association between ESG disclosure policies and household welfare. Finally, our study was based on ESG disclosure policies and the enterprise value of HPE only. Other studies can assess how the ESG disclosure policies affect other sections of the HPE.

Credit author statement

Ya Cheng: Writing – review & editing, Writing – original draft, Supervision, Formal analysis. Changqing Li: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. Martinson Ankrah Twumasi: Writing – review & editing, Supervision. Ya Deng: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. Yan Liu: Writing – original draft, Formal analysis, Conceptualization. Yan Liu: Writing – review & editing, Writing – original draft, Formal analysis, Data curation

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Data availability statement

The data are not publicly available due to privacy restrictions but will be available on request.
Ethics approval: Not Applicable.
Consent to participate: Participants consent was requested and received.
Consent for publication: Not Applicable.
Code availability: Not Applicable.

Appendix

Abbreviations Full Name

ESG	Environmental, Social and Corporate Governance
HPE	HPE
SOE	The State-Owned Enterprises
DID	The Differences-in-Differences, a measurement method
PSM-DID	The Propensity Score Matching-Differences in Differences
R&D	Research and development

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