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Does Environmental Information Disclosure Make Firms' Investments More Efficient? Evidence from Measure 2007 of Chinese A-Listed Companies

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Abstract: Using a sample of 2822 Chinese A-listed firms over the 2002–2015 period and the propensity score matching with difference-in-differences (PSM-DID) approach, we estimate the causality of environmental information disclosure (EID)'s impact on investment efficiency based on a quasi-experiment in 2007. This paper finds strong and robust evidence that there is a significant positive connection between EID and company investment efficiency in China. We further determine that heterogeneity of EID's performance appears in the different settings of industry and subdivision industries. The significance of several sub-industries disappeared while the others retained larger significant coefficients than the whole industry case. The probability that an enterprise issues an environmental annual report has a significant positive link with investment efficiency in heavy industry, while this relationship is weakened or even not obvious in non-heavy polluting industries. Finally, we find that employee compensation serves as a mediator from which EID has an indirect effect on investment efficiency. Our results confirm that EID plays a vital role in firm-level capital allocation efficiency.

Keywords: environmental information disclosure; investment efficiency; corporate social responsibility; corporate financial performance

1. Introduction

After command-and-control and market-based regulation approaches, environmental information disclosure (EID) has been characterized as the “third wave” of environmental regulation [1]. More and more evidence shows that the public disclosure of environmental information generates significant and important impacts on pollutant reduction and environmental performance in the U.S., Latin America, and Asia [2,3], and also in China [4–7].

In China, the State Environmental Protection Agency (SEAP), which is the predecessor of the Ministry of Environmental Protection (MEP), has also launched a program of Green Watch Program, which is considered as an early-stage form of EID and supported by the World Bank's InfoDev Program in 1998. China started the pilot of the Green Watch Program in several cities, such as Zhenjiang in Jiangsu and Hohhot in Inner Mongolia, in 1998. It was then demonstrated that the program was an effective environmental regulation tool in terms of environmental performance by valuable researches [6,8–10]. Thereafter, Zhejiang, Anhui, Shandong, Chongqing, and more provinces have joined the pilot program and the SEAP has promoted this program in the nationwide-scope in 2007 when the Measure on Environmental Information Publicity (on Trial) (Measure 2007) was officially carried out [8].

Following the Measure 2007, the Guide to Environmental Information Disclosure for Listed Companies (Guide 2008) was also introduced by Shanghai Stock Exchange in 2008, which indicates that real-time pollution information for Chinese listed companies is available and the investor can respond to it more efficiently. The Guide 2008 requires Chinese listed companies to report environmental-related reports in two cases. On one hand, if the company is labeled as a “heavy polluter” or punished by the provincial environmental protection department, an environmental interim report (EIR) within two days is required. On the other hand, environmental annual reports (EAR) in various forms are encouraged for the companies that have great impact on the environment. Thereafter, the EAR was compulsively required in 2010 for those listed companies of heavy pollution industries through the Guidelines to Environmental Information Disclosure for Listed Companies (Guidelines 2010), which is another new guide upgraded by the MEP.

To evaluate the performance of environmental information disclosure arrangement in China, we divide these researches defining EID into two categories: one is based on content analysis of reports and the other uses dummies. In the first category, many pieces of research have focused on the annual environmental report or the corporate social report (CSR), including voluntary and compulsory forms [5,11–15]. Some research has focused on content analysis based on global reporting initiative guidelines (GRI) and the most cited voluntary environmental information disclosure index was developed by Clarkson et al. (2008) [16]. Clarkson et al. (2013) used this index to reveal the effect of the Toxics Releases Inventory in the U.S., and Braam et al. (2016) applied this index to evaluate the level and nature of voluntary environmental information disclosure in Dutch companies [17,18].

Another new branch of policy research focuses on simple dummy settings. More dummy settings can be found in the literature on the difference-and-difference analysis of environmental policy. Currie, Greenstone, and Moretti (2011) examined the effect of Superfund site cleanups on infant health using three dummies: the first dummy is set as 1 if mothers live within 2000 m of the site, otherwise as 0 if living between 2000 and 5000 m away; the second dummy is set to be 1 if the birth occurred during the site cleanup; and the third is set as 1 if the birth occurred after the cleanup [19]. Greenstone and Hanna (2014) used policy dummies to explore the infant mortality effect of the Supreme Court Action Plans and the mandatory use of catalytic converters on air pollution and the National River Conservation Plan on water pollution in India [20]. Fu and Gu (2017) used two dummies to explain the increasing air pollution by highway tolls waiver in China, in which one dummy was set as 1 if on a day highway tolls were waived, and the other was set to be 1 on the national days [21]. Boslett, Guilfoos, and Lang (2016) use a state dummy of Pennsylvania and New York and a period dummy of pre-moratorium and post-moratorium to estimate the double difference of the local impacts of shale gas development [22].

No matter what kind of EID was adopted in the literature, both positive and negative performances of EID were revealed. Comparative analysis of pilot cities of the Green Watch Program suggested that it did have a significant impact on environmental performance [6], and more firm-level data has also demonstrated that the program encouraged firms to improve and disclose their environmental performance [8,23]. The positive effect suggests that companies need to deliver positive information to stakeholders for their reputation, in order to get their support, reduce the cost of capital, or lessen the environmental regulation stringency [24–28]. The related research found that firms with higher CSR performance often invest more efficiently [29–31], while the negative effect complains that investors respond negatively to positive CSR news, likely resulting from agency problems [32]. In addition, the performance of EID may also be conditional. Meng et al. (2014) have pointed out that the poor environmental performer often tries to avoid disclosure of negative environmental information, although voluntary and compulsory environmental information disclosure will perform differently [5,14,33].

To the contrary of these former studies on EID performance, this paper firstly focused on the pure policy effect of environmental information disclosure using the difference-in-difference (DID) method based on Chinese A-listed companies from 2002 to 2015. First, following the pilot program, China’s SEAP and MEP carried out the Measure 2007, Guide 2008, and Guidelines 2010 to promote the

disclosure of environmental information. There have been much research done about the performance evaluation of EID programs but none about the policy evaluation of EID. To the best of our knowledge, this paper firstly contributes the pure policy effect evaluation of EID using Chinese listed company data. Second, more precisely, it contributes an estimation of public disclosure based on the design of natural experiments of the EID, such as combining compliance data from Green Watch implementation areas from which only conventional regulation has been applied [6]. This paper tries to design a quasi-experiment through the setting of sub-division industries to precisely estimate the pure policy effect of EID and reveal the policy effects of the sub-division industries. This paper verifies the causality between EID and investment efficiency, and the significant positive correlation between CSR and CFP was confirmed here. Our research provides a theoretical basis for the emerging ESG investment and finds the positive effect of environmental regulation on the economy.

The remainder of our paper is unfolded as follows. Section 2 firstly estimates the investment efficiency of Chinese listed companies. Section 3 presents EID's impact on investment efficiency, and further discussion is conducted in Section 4. The Section 5 discusses the influence mechanism. Finally, we conclude this paper and provide some policy suggestions.

2. Investment Efficiency of Chinese A-Listed Companies

We consider two models of investment efficiency. We first measure the investment inefficiency based on Biddle et al. (2009) [34].

$$Invest_{i,t} = \beta_0 + \beta_1 growth_{i,t-1} + \sigma_{i,t} \quad (1)$$

$Invest_{i,t}$ is the new investment expenditure calculated as the single-year capital expenditure, which is divided by total assets at the beginning of the year. Capital expenditure is calculated as the sum of a series of net value, including fixed expenditure, long term investment in construction, engineering, and intangible assets. $growth_{i,t-1}$ is the growth rate of sales during the last year. To control for industry- and time-related effects, Model (1) is estimated for each industry year and CSRC industry classification is used to segment industries. Model (1) needs this segmented industry to have at least 20 observations in a given year. We calculate three measures of investment inefficiency based on this residual. We use the absolute value of residuals to measure the overall magnitude of investment inefficiency, which means that the larger the absolute value, the lower the efficiency. A positive residual would indicate over-investment and a negative residual means under-investment. So we define the variables "Overinvestment" (Over Invest) and "Underinvestment" (Under Invest) as the residual of Model (1) when the residual is positive and negative.

$$Invest_t = \alpha_0 + \alpha_1 Q_{t-1} + \alpha_2 Cash_{t-1} + \alpha_3 Leverage_{t-1} + \alpha_4 Size_{t-1} + \alpha_5 Age_{t-1} + \alpha_6 Stock\ Return_{t-1} + \alpha_7 Invest_{t-1} + \sum \beta_j * Year_j + \gamma_0 heavy + \delta_t \quad (2)$$

We construct an alternate Model (2) of investment efficiency based on Richardson (2006) [35], in which a comparative study using different measurement methods makes sense. Deviations from this prediction captures inefficient investment. We define the overall magnitude of inefficient investment and Over- and Under Invest in the same way as Biddle et al. (2009). Q equals Tobin Q of the company. Cash means operating cash flow divided by total assets. Leverage is set as liability divided by total assets. Size is calculated with natural logarithm of total assets. Age means the year that the company has been listed. Stock Return is the stock returns of the company.

Our sample comprises of data during 2002–2015 of listed companies in Shanghai and Shenzhen A-share markets, with ST and financial companies excluded. We get the distribution of the heavy-polluting sample of the subdivision industries from Table 1. We start in 2003 because a large sum of company characteristic data starts in 2002. We winsorize all continuous variables at the top and bottom 1-percent of their distributions. Company characteristics and financial data in this paper come from the China Stock Market and Accounting Research database (CSMAR). We collected

3769 environmental annual reports and 65 environmental interim reports from the Stock Exchange web and Cninfo net by hand, in which 1689 and 58 belong to heavy-pollution firms. Table 2 presents descriptive statistics for the investment efficiency sample. The investment inefficiency, based on Biddle et al. (2009) and Richardson (2006), suggests that the median firm deviates by about 3.81 percent (3.61) of total assets. This ratio is 3.5 percent in Cook et al. (2017) [29]. The average return on assets (ROA) is 4.1%, and the proportion of large shareholders is 37.7%. Table 2 reports descriptive statistics of all variables. The gap of investment efficiency over time is shown in Figure 1.

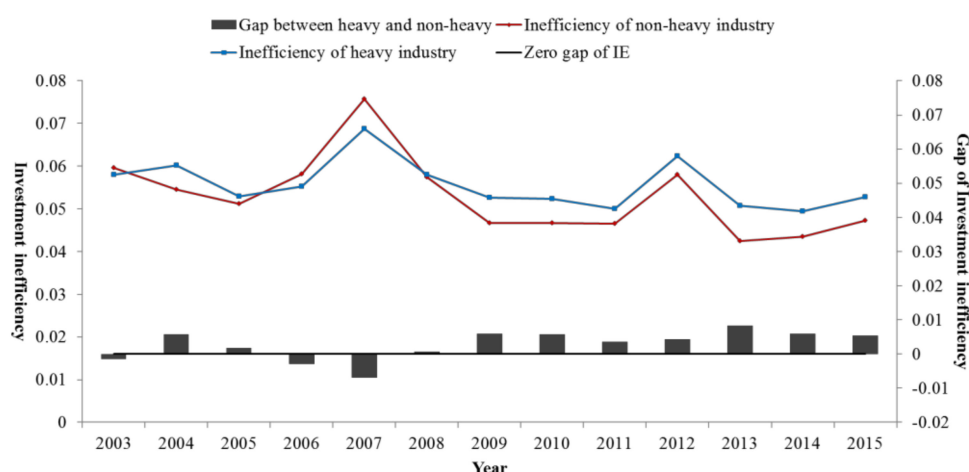


Figure 1. Investment inefficiency.

Table 1. The distribution of the sample.

Industry	Number of Firms			Inefficiency	
	All	SH	SZ	Biddle (2009)	Richardson (2006)
All the A share listed companies	2822	1070	1752	0.051	0.051
Heavy pollution industry	1077	430	647	0.056	0.054
Non heavy pollution industry	1745	640	1105	0.047	0.049
Extractive industry (B)	79	46	33	0.065	0.055
Food and beverage manufacturing (C0)	111	47	64	0.050	0.041
Textile, clothing and fur manufacturing (C1)	75	30	45	0.053	0.043
Paper and printing (C3)	42	15	27	0.056	0.044
Oil, chemicals, plastics, plastics (C4)	276	84	192	0.058	0.062
Metal and nonmetal manufacturing (C6)	228	93	135	0.054	0.059
Pharmaceutical and biopharmaceutical (C8)	170	59	111	0.046	0.048
Electricity, gas and water production (D)	96	56	40	0.072	0.057

Notes: The table reports the distribution of the sample on the Shanghai Stock Exchange (SH) and the Shenzhen Stock Exchange (SZ). The heavy polluting industries are defined by the China Securities Regulatory Commission (CSRC) in 2001, following existing literature.

Table 2. Descriptive statistics.

Variable	Mean	St. Dev	Median	Max	Min	N
Inefficiency (Biddle et al. (2009))	0.051	0.054	0.038	0.367	0.001	19232
Inefficiency (Richardson (2006))	0.051	0.054	0.036	0.303	0.001	20770
top1	0.377	0.158	0.361	0.761	0.091	20077
leverage	0.452	0.207	0.461	0.912	0.047	20090
growth	0.197	0.41	0.136	2.667	−0.594	18269
roa	0.041	0.053	0.037	0.197	−0.206	20090
lnage	1.724	0.959	1.946	3.045	0	20090
mshare	0.064	0.155	0	0.656	0	20077
fixeradtio	0.256	0.178	0.222	0.753	0.003	20084

3. EID's Impact on Investment Efficiency

3.1. Literature Review and Hypotheses Development

The extant literature has examined the effect of EIDs on corporate financial performance (CFP). The first view is positive. According to the theory of signals, firms have a strong incentive to disclose environmental information to reduce information asymmetry [24,36], which helps to solve agency problems. Ioannou and Serafeim (2017) have found that regulations mandating the disclosure of environmental information in China increase the firm's valuations, reflected as Tobin's Q [37]. Dam and Scholtens (2015) have proved a positive relationship between CSR and financial performance, including the market-to-book ratio, ROA, and stock market return [25]. Alternatively, the opposite view on EID argues that EID is a manifestation of agency problems [32], and EID is costly for shareholders. Managers may pursue individual goals and gain private benefits from EID. Environmentally-friendly firms or managers tend to adopt a high standard of behavior consistent with their EID goals without considering the interests of stakeholders. Firms may not have sufficient resources to finance growth if investing in EID. Chih et al. (2014) proved that CSR leads to larger asymmetric information and higher agency problems [38].

Investment efficiency can reflect the ability of the company to invest optimally as a function of potential growth. Enterprises with high investment efficiency are less likely to underinvest or overinvest. There are two widely used methods to measure investment efficiency. Richardson (2006) decomposed investment expenditure into new investment expenditure and required investment expenditure to maintain assets in place, so the margin of the equation is inefficiency [35]. In order to be as efficient as possible, the model needs to control the characteristics of the firms, time difference, and so on. Biddle et al. (2009) constructed an expected investment model by estimating investment expenditure as a function of growth opportunities of the company for each industry-year [34]. A positive residual means over-investment, and a negative residual indicates under-investment. There are a number of influential studies on the factors that determine the investment efficiency of companies, such as ownership type [39], management characteristics [40], the separation of ownership and control [39,41], government intervention [42], investor protection [43] and so on, from which we can get that the key to improving the efficiency of enterprise investment is to reduce information asymmetry and agency costs.

Disclosure of information may have some impact on corporate investment efficiency. The scholars have proved that higher-quality reporting of accounting information reduces information asymmetries between managers and shareholders, which improve investment efficiency [34,42,44]. Al-Hadi et al. (2017) found that market risk disclosures (MRDs) significantly improve investment efficiency, which attributed to reducing information asymmetry [45]. At present, there is still a lack of research to empirically assess the effect of EID on investment efficiency, and most existing studies are based on CSR on investment efficiency. Just like the research of EID on corporate financial performance, the impact of EID on investment efficiency can also be divided into two categories. The attitude of the first group is negative. Bhandari and Javakhadze (2017) proved that CSR negatively affects firm-level capital allocation efficiency, which is moderated by agency conflict, stakeholder engagement, as well as financial slack. The second group believes that EID does have a positive impact on investment efficiency, for it eliminates information asymmetry and agency costs [46]. CSR reduces agency problems and asymmetric information, which leads to an increase in investment efficiency. Benlemlih and Bitar (2018) have found a positive effect of CSR on investment efficiency in U.S. firms from 1998–2012, which was confirmed by Cook et al. (2017) using the data from 1992 to 2009 [29,47]. Information asymmetry, which the most important role of environmental information disclosure aims to reduce, is one of the important reasons for principal–agent problems. Enterprises with more environmental information disclosure can gain more stakeholders' recognition and should have higher investment efficiency.

Hypothesis: Environmental information disclosure will reduce information asymmetry and ultimately improve the efficiency of corporate investment.

3.2. Empirical Analysis

Measures 2007 specifies companies to publish environmental information, especially listed company in heavy industries. The regulation was strengthened by the stock exchange later because it could have a greater impact on the stock price. So there is a significant difference in the degree of EID regulation in heavily polluting industries and other industries after 2007. We can set up a virtual variable to distinguish whether EID regulation is carried out. We define the variable EID as a dummy that takes on the value of 1 since 2007, 0 otherwise.

$$\text{Efficiency}_{it} = \alpha_0 + \alpha_1 \text{EID}_t + \alpha_2 \text{heavy}_i + \alpha_3 \text{EID}_t * \text{heavy}_i + \sum \tau_j * X_j + \sum \beta_j * \text{year}_j + \varepsilon_{it} + \sigma_i \quad (3)$$

We use Equation (3) to examine the net effect of the policy on investment efficiency. EID is the dummy variable that takes on the value of 1 after 2007. Heavy is an indicator variable that takes on the value of 1 if the company belongs to a heavy-pollution industry, and 0 otherwise. Consistent with the existing literature, X_j is a vector of firm characteristics such as control variables, including the proportion of large shareholders, financial leverage, company growth, profitability, management stock ownership, and fixed assets ratio. The definitions of all the variables are summarized in Table A1. All of the control variables are lagged one period to eliminate possible endogeneity. We use Table 1 to represent the distribution of the samples, and Table 2 to represent descriptive statistics.

We are most interested in α_3 . When we carry out the research on policy evaluation, the result may be caused by many reasons. The main challenge for this kind of research is to distinguish the effect of the regulation itself from other effects. At present, difference-in-differences (DID) is a common and scientific method in the study of policy evaluation because of the existence of the treatment effect. The net effect of policy changes can be obtained in DID. The premises of the effectiveness of DID are random grouping and homogeneity of the sample, which is often not satisfied. There were significant differences between the company of the treatment group and the control group in this paper, so DID may not be appropriate. Homogeneity can be made up by propensity score matching (PSM). Propensity score matching with difference-in-differences (PSMDID) can control unobserved and non-time-varying differences between groups; it can make up for the shortcomings of DID to some extent. We choose PSMDID to study the effect of the implementation of the policy on investment efficiency in Equation (2). We calculate the matching score using the proportion of the largest shareholder, company growth, years of listing, management stock ownership, and fixed assets ratio. Then we use Equation (2) to estimate, with financial leverage and profitability as control variables. The definitions of all the matching variables and control variables are summarized in Table A1. The type and bandwidth of the Kernel function are epanechnikov and 0.06 as the defaults in this paper. The estimation of the propensity score is the logit model. The default control group includes all other non-polluting companies.

It can be seen from the propensity score density (Figure 2) that there is a significant difference in the propensity score distribution between the heavy-pollution industries and other industries, which indicates that there may be significant differences among groups. The t -test before the matching also proved that the companies between the treated group and the control group differed significantly. The assumptions of the DID cannot be met so we use PSMDID as a remedy.

The results of PSMDID indicate that there is a negative connection between EID, represented by the implementation of the policy, and investment inefficiency. In all four models in Column (3) to (6) of Table 3, the coefficients for pure effect for the policy have the predicted negative sign and are significant ($p < 0.1$, or better), which are economically significant as well. The policy after 2007 significantly improves the investment efficiency of heavy polluting companies by 1.2% (0.59%), compared with the companies in non-heavy industries. Heavily polluting industries have relatively low investment efficiency, which we can get from the coefficients of industry grouping variable *heavy*. In order to eliminate the differences between the control group and the treatment group, we performed PSM within the manufacturing sector in Columns (4) and (6) of Table 3, and the results did not significantly change.

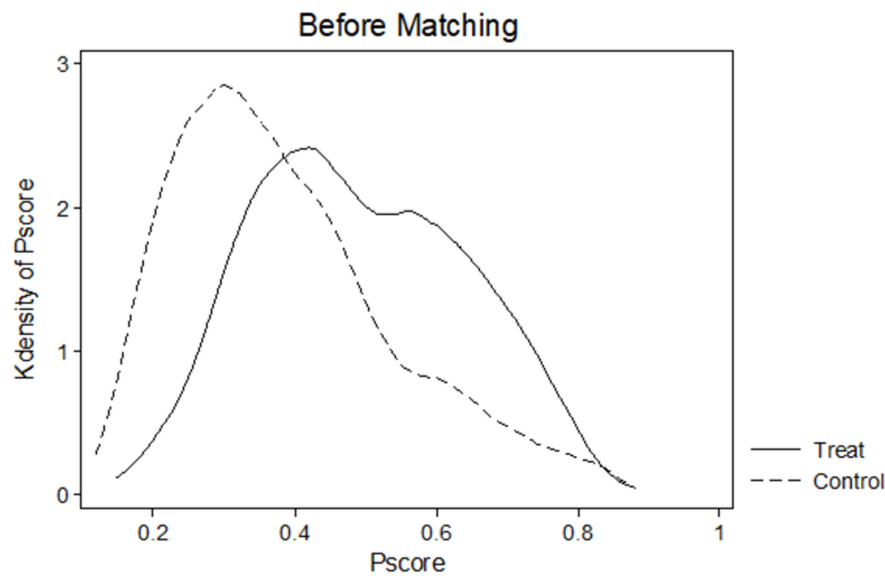


Figure 2. Propensity score density.

Table 3. The net effect of the policy on investment efficiency.

	(1)	(2)	(3)	(4)	(5)	(6)
	Biddle et al. (2009)			Richardson (2006)		
Inefficiency	DID	DID	Full Sample	Intra Industry	Full Sample	Intra Industry
EID	−0.0021 (0.0014)	0.0017 (0.0016)	−0.0007 (0.0023)	−0.0003 (0.0037)	0.0051 *** (0.0017)	0.0045 (0.0028)
Heavy	0.0161 *** (0.0023)	0.0113 *** (0.0025)	0.0107 *** (0.0029)	0.0112 ** (0.0044)	0.0029 (0.0022)	0.0093 *** (0.0029)
Heavy * EID	−0.0101 *** (0.0024)	−0.0104 *** (0.0026)	−0.0122 *** (0.0030)	−0.0131 *** (0.0044)	−0.0059 ** (0.0024)	−0.0055 * (0.0033)
X	NO	Yes	Yes	Yes	Yes	Yes
Constant	0.0497 *** (0.0014)	0.0491 *** (0.0029)	0.0528 *** (0.0027)	0.0457 *** (0.0035)	0.0606 *** (0.0022)	0.0494 *** (0.0031)
Observations	18,897	17,957	17,957	10,209	18,685	10,606
Adj. R-squared	0.0089	0.0278	0.0064	0.0077	0.0058	0.0060

Notes: The table reports the results of DID estimates. Columns (1) and (2) are the results of DID, while the others are from PSMDID; the sample includes only the companies from the manufacturing industry in Columns (4) and (6); clustered std. errors by the firm are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; In all the results, we control the time and individual fixed effects.

The accuracy of the results depend on the applicability of the method. From Table 4, we find that there is a significant difference between almost all of the matching variables in the nonpolluting firms and heavy polluting firms. After PSM, there is no obvious gap between the two groups with the support of various tests. PSM also significantly improved the residual deviation. So we have every reason to believe that the results of PSMDID are credible.

Table 4. Balance test for PSM.

Variable	Unmatched	Mean			% Reduct Bias	t	$p > t $
	Matched	Treated	Control	%Bias			
inefficiency	U	0.054	0.050	7.6	86.7	5.41	0.000
	M	0.056	0.055	1.0		0.32	0.750
top1	U	0.384	0.366	11.2	45.1	8.44	0.000
	M	0.430	0.420	6.2		1.83	0.067
growth	U	0.175	0.197	−5.3	12.7	−3.73	0.000
	M	0.229	0.210	4.6		1.56	0.118
lnage	U	1.782	1.736	4.9	78.3	3.61	0.000
	M	1.6794	1.690	−1.1		−0.47	0.638
mshare	U	0.055	0.076	−13.9	99.6	−10.19	0.000
	M	0.001	0.001	0.1		0.37	0.709
fixedratio	U	0.331	0.200	79.1	99.3	59.20	0.000
	M	0.387	0.388	−0.5		−0.16	0.874
joint inspection			Pseudo R2	LR chi2	$p > \chi^2$	MeanBias	MedBias
Unmatched			0.105	2941.00	0.000	20.3	9.4
Matched			0.001	5.70	0.458	2.2	1.0

We believe that this effect is mainly achieved by reducing information asymmetry and increasing stakeholder agreement. Corporate investment decisions are clearly incomplete information behavior, especially in China, with an incomplete market economy and the influence of the government still being very strong. China has gradually moved from a planned economy to a market economy, but the former continues to influence individual decision-making thinking. If the prices of factors are distorted, the efficiency of investment decisions will be affected. According to reputation theory, in the context of incomplete information, environmental information disclosure can effectively improve decision-making efficiency. Stakeholder identification can reduce the difficulty of obtaining suitable production factors and reduce transaction costs. The savings in transaction costs will also affect the efficiency of corporate decision-making behavior.

4. Further Discussion

Environmental information disclosure reduces excessive investment and improved underinvestment, as we can see in Table 5. Companies with better environmental performance prefer to disclose a higher level of environmental information than others. We can find that the firms that have better environmental performance disclose a greater proportion of hard-disclosure items. Analysis of both the level and nature of disclosures means that the environmental information disclosure reflects their environmental performance. We can argue that the disclosure of environmental information improves the efficiency of the company's investment. We have done many robustness tests for the above conclusions. In order to eliminate the possible errors of the PSM estimation method, we have replaced the type of the matching function, the bandwidth of the kernel function, and specified logit estimation of the propensity score. Our results are not sensitive to the choice of matching procedures, and alternative matching procedures yield very similar results. We also take into account the difference between state-owned enterprises and non-state-owned enterprises and the problem of the balance sample, and the result is consistent. All of the robustness tests are consistent that the implementation of the policy improves the investment efficiency of the enterprise.

Table 5. Underinvestment and overinvestment.

	(1)	(2)	(3)	(4)
	Biddle et al. (2009)		Richardson (2006)	
Inefficiency	Under Invest	Over Invest	Under Invest	Over Invest
EID	0.0009 (0.0013)	−0.0079 (0.0058)	−0.0112 *** (0.0030)	−0.0006 (0.0023)
Heavy	−0.0089 *** (0.0017)	0.0111 (0.0070)	−0.0030 (0.0030)	0.0023 (0.0032)
Heavy * EID	0.0048 *** (0.0017)	−0.0137 * (0.0075)	0.0117 *** (0.0036)	−0.0007 (0.0034)
X	Yes	Yes	Yes	Yes
Constant	−0.0411 *** (0.0020)	0.0744 *** (0.0067)	−0.0626 *** (0.0034)	0.0603 *** (0.0028)
Observations	12,141	6116	9636	9042
Adj. R-squared	0.0175	0.0091	0.0140	0.0023

Notes: Robust parentheses adjusted for firm-level clustering are reported in parentheses. *** $p < 0.01$, * $p < 0.1$. In all the results, we controlled the time and individual fixed effects.

One of the important assumptions of DID is parallel trends between the treatment and control groups. Although Figure 1 shows this point intuitively, we needed further tests and conducted a placebo test to examine it. We find that the coefficients of the three interaction terms (see Table 6) are not statistically significant, indicating that before 2007, environmental information disclosure did not significantly increase the efficiency of investment. In order to determine whether the emission reduction effect was caused by the policy of 2007, we use interaction terms of year dummy variables from 2008 to 2015 and Heavy. Table A3 shows related regression results and they are not significant. That effect appears from the regulation in 2007. We conclude that the treatment and control groups satisfy the common trend hypothesis.

Table 6. Placebo test.

	(1)	(2)	(3)	(4)
2006 * Heavy	−0.0072 (0.0048)			−0.0078 (0.0053)
2005 * Heavy		−0.0031 (0.0034)		−0.0041 (0.0040)
2004 * Heavy			0.0003 (0.0028)	−0.0011 (0.0034)
2007 * Heavy	−0.0140* (0.0069)	−0.0135 * (0.0067)	−0.0132 * (0.0068)	−0.0145 ** (0.0070)
Constant	0.0744 *** (0.0080)	0.0743 *** (0.0080)	0.0742 *** (0.0082)	0.0748 *** (0.0084)
X	Yes	Yes	Yes	Yes
Observations	17,910	17,910	17,910	17,910
Adj.R-squared	0.0252	0.0249	0.0249	0.0253

Notes: Robust parentheses adjusted for industry-level clustering are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In all the results, we controlled the time and individual fixed effects. The coefficients of the other control variables are consistent with the benchmark regression in Table 3.

In order to understand the heterogeneity of policy impact on the companies in heavy-pollution industries, we construct PSM for a two-digit industry in manufacturing, because there is no suitable controlling group from non-heavy pollution industries. From Table 7, we find that the policy of

EID after 2007 does not have a significant impact on the companies in C0, C1, and C3, although their coefficients are negative. The effect of the policy is more obvious in the C4 and C6 industries. We perform the estimates that test the magnitude of overinvestment (positive residuals from Model (1) and 2) and underinvestment (negative residuals from Models (1) and (2)) in C4, C6 and C8, which show that the policy after 2007 reduces overinvestment and improves underinvestment.

Table 7. Matching within the manufacturing sector.

	(1)	(2)	(3)	(4)	(5)	(6)
Inefficiency	C0	C1	C3	C4	C6	C8
EID	0.0011 (0.0024)	−0.0009 (0.0025)	−0.0045 (0.0076)	0.0013 (0.0048)	−0.0023 (0.0045)	0.0001 (0.0026)
Heavy	0.0034 (0.0045)	0.0076 (0.0081)	0.0206 (0.0160)	0.0136 ** (0.0069)	0.0160 ** (0.0070)	0.0045 (0.0040)
Heavy * EID	−0.0043 (0.0050)	−0.0053 (0.0083)	−0.0234 (0.0162)	−0.0135** (0.0066)	−0.0197 *** (0.0070)	−0.0082 * (0.0043)
X	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0491 *** (0.0021)	0.0492 *** (0.0025)	0.0584 *** (0.0074)	0.0534 *** (0.0050)	0.0555 *** (0.0049)	0.0482 *** (0.0023)
Observations	5003	4691	4520	5996	5777	5357
Adj.R-squared	0.000	0.002	0.016	0.004	0.013	0.003

Notes: Robust parentheses adjusted for industry-level clustering are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Control group is the non-heavy industry in manufacturing industry. Food and beverage manufacturing (C0); textile, clothing and fur manufacturing (C1); paper and printing (C3); oil, chemicals, plastics, plastics (C4); metal and nonmetal manufacturing (C6); pharmaceutical and biopharmaceutical (C8). In all the results, we controlled the time and individual fixed effects.

We set up a dummy variable, EAR, to measure whether the annual report on environmental information is released for the company this year. The distribution of EAR and EIR in various industries is provided in Table A2. Table 8 reports the effect on corporate investment efficiency due to annual stand-alone reports with environmental information. There is a negative and significant (at the 10% level) connection between EAR and company investment efficiency as a whole. The companies that publish EAR are 0.86 percent (0.32 percent) more efficient in capital allocation than other companies following Biddle et al. (2009) and Richardson (2006). EAR has a more significant effect on investment efficiency in heavy industry, while this relationship is weakened or even not obvious in non-heavy polluting industries.

Table 8. Environmental Annual Report on investment efficiency.

	(1)	(2)	(3)	(4)	(5)	(6)
	Biddle et al. (2009)			Richardson (2006)		
Inefficiency	Full Sample	Heavy	Non-Heavy	Full Sample	Heavy	Non-Heavy
EAR	−0.0086 *** (0.0018)	−0.0102 *** (0.0030)	−0.0073 *** (0.0022)	−0.0032 ** (0.0016)	−0.0045 * (0.0025)	−0.0028 (0.0020)
Constant	0.0855 *** (0.0337)	0.1069 *** (0.0336)	0.0706 *** (0.0326)	0.0665 *** (0.0255)	0.0748 *** (0.0239)	0.0603 *** (0.0259)
Year and industry	Yes	Yes	Yes	Yes	Yes	Yes
X	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,809	7416	10,393	18,153	7413	10,740
Adj. R-squared	0.182	0.172	0.192	0.109	0.0760	0.133
Hausman	156.31 ***	92.08 ***	79.53 ***	87.32 ***	33.58 ***	66.81 ***

Notes: Robust parentheses adjusted for industry-level clustering are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In all the results, we controlled the time and individual fixed effects with a bootstrap Hausman test, performing 2000 bootstrap replications. The results of the F- and BP tests suggest that OLS is not appropriate. The Sargan–Hansen test has been used to select from fixed effect and random effect, and the results are consistent with the Hausman test. Robust parentheses adjusted for firm-level clustering are reported in parentheses.

The decision to publish stand-alone reports may not be randomly distributed, which can be influenced by firm operating, share price, environmental performance, and so on. We adopt the Heckman two-stage approach to eliminate self-selection bias. We estimate a probit model of whether firms publish stand-alone reports with environmental information, from which we get the inverse Mills ratio as an additional explanatory variable in the main models reported in Table 9. The inverse Mills ratio is significant, so we can conclude that self-selection is an important consideration in this research. The effect of stand-alone reports on investment efficiency is still significant, although the coefficients have changed. The impact of stand-alone reports on investment efficiency is reduced when we focus on the measure based on Biddle et al. (2009), but it increases following Richardson (2006). The coefficients of the two methods are close, controlling self-selection bias.

Table 9. Heckman two-steps regressions on investment efficiency.

	(1)	(2)	(3)	(4)	(5)	(6)
	Biddle et al. (2009)			Richardson (2006)		
Variables	Full Sample	Heavy	Non-Heavy	Full Sample	Heavy	Non-Heavy
EAR	−0.0054 *** (0.0011)	−0.0047 ** (0.0019)	−0.0057 *** (0.0015)	−0.0044 *** (0.0011)	−0.0043 *** (0.0016)	−0.0043 *** (0.0014)
X	Yes	Yes	Yes	Yes	Yes	Yes
Inverse Mills Ratio	0.0261 *** (0.0057)	0.0662 *** (0.0088)	0.0104 (0.0074)	0.0225 *** (0.0087)	0.0355 *** (0.0120)	0.0282 ** (0.0111)
Constant	0.0303 *** (0.0035)	0.0128 ** (0.0059)	0.0375 *** (0.0045)	0.0537 *** (0.0026)	0.0582 *** (0.0038)	0.0489 *** (0.0034)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,816	8125	11,691	18,569	7539	11,030
Wald test	640.9 ***	245.1 ***	470.2 ***	610.9 ***	129.9 ***	652.5 ***

Notes: Robust parentheses adjusted for firm-level clustering are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$.

5. Mechanism Discussion

In an attempt to identify the channels through which EID affects company performance, EID may affect business activities in the labor market. EID can maintain the normal interests of employees because of transparency, which makes sense in developing countries where employee benefits are difficult to protect. Flammer and Luo (2016) have proved that CSR is positively connected with labor productivity through increased employee satisfaction and mitigation of adverse behavior [48]. Interim reports with negative environmental information are suitable to measure the negative environmental information disclosure and mandatory information disclosure. We define the variable EIR as a dummy that takes on the value of 1 if the company publishes an interim report with negative environmental information this year. The average causal mediation effect (ACME) is introduced by Imai et al. (2010) to investigate alternative causal mechanisms by examining the roles of intermediate variables, which is more effective than the Sobel test [49].

The results related to the causal mediation analysis of employee compensation are reported in Table 10. The ACME, our estimate of interest, is 0.0017, which suggests that the mediated portion of accounting investment efficiency attributed to interim reports is 0.17 percent of the total effect. The 95% confidence interval of ACME does not include zero and the Sobel Goodman test is also significant. There is a positive connection between employee motivation and company investment efficiency in Table 10, which means the staff's devotion and loyalty are critical to improving company investment

efficiency and are consistent with the employee motivation theory. Environmental interim reports have a significant positive effect on employee motivation, which is consistent with the relevant research that EID increases the market value of enterprises. The increase in employee responsibility is always accompanied by a reward in incentives. Improvement of EID will significantly improve company investment efficiency through employee compensation.

Table 10. Mediating effect of employee compensation.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln salary	Inefficiency	inefficiency	inefficiency	inefficiency	inefficiency
EAR	0.1101 ** (0.0491)	−0.0043 (0.0054)			−0.0040 (0.0054)	−0.0183 (0.0824)
lnsalary			−0.0030 * (0.0016)		−0.0030 * (0.0016)	−0.0030 * (0.0016)
lnsalary *EAR				−0.0002 (0.0003)		0.0007 (0.0042)
X	Yes	Yes	Yes	Yes	Yes	Yes
Constant	17.4554 *** (1.1420)	0.0659 *** (0.0256)	0.1178 *** (0.0251)	0.0659 *** (0.0256)	0.1177 *** (0.0251)	0.1177 *** (0.0251)
Year and industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,196	18,153	18,151	18,151	18,151	18,151
Adj.R-squared	0.907	0.109	0.109	0.109	0.109	0.109
Bootstrap hausman	254.59 ***	99.52 ***	64.37 ***	99.56 ***	65.33 ***	65.28 ***
	Mean		Low limit	Upper limit	% of Total Effect mediated	
ACME	−0.0017		−0.0031	−0.0005	17.21%	
Sobel test	−2.33 ***				21.56%	

Notes: Robust parentheses adjusted for firm-level clustering are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Hausman, ACME and Sobel tests all performed 2000 bootstrap replications. In VARIABLES, lnsalary means natural logarithm of employee compensation.

6. Conclusions

We find strong and robust evidence that the policy of environmental information disclosure by MEP significantly improves the investment efficiency in heavily polluting industries relative to others. The economic effect of EID regulations appears to be positive, and the quasi-experimental design using Measure 2007 makes the results more credible. The heterogeneity of coefficients in a segmented industry means that the effectiveness of the policy depends on the industry. EAR as a proxy variable has a more significant effect on investment efficiency in heavy industry, while this relationship is weakened or even not obvious in non-heavy polluting industries. Our findings are robust to alternative variable measurements as well as tests for research methods. We have discovered the channel of EID to influence investment efficiency, which has implications for related research. With these findings, this paper contributes to the literature that explores the capital allocation efficiency of EID regulations. Existing research provides evidence that EID has promoted firms to improve environmental performance, and the results of this paper extend the literature on the economic implications of disclosure regulation.

Based on the above research, we have some suggestions for future research and policy applications. It is more accurate to measure EID by environmental annual reports because they can truly reflect the environmental efforts of the company. In this paper, we simply used whether to publish the report and did not score the content of the report, due to a limit in data. It is necessary to systematically interpret all the contents of the report and set up an objective EID database such as Kinder, Lydenburg, and Domini (KLD) Research & Analytics in CSR. We did not consider the impact of firm location and political geography, which is so important and should be the direction of further research. We need to consider the causal effect between environmental information disclosure and the financial performance of the company. In this paper, we only considered the impact of policy on investment efficiency, but there may also be selective bias. Just like Zeng et al. (2012) [50], there are many factors that affect the environmental information disclosure of enterprises.

Our result is consistent with the relevant research that EID can improve corporate operations and performance. So we should increase the intensity of enforcement and punishment in the regulations of EID. All kinds of environmental information disclosure should be encouraged. The policy of EID should pay more attention to the perspective of green finance because the enterprise is most sensitive to it. For the listed companies with negative environmental reports, environmental regulatory authorities should require the largest shareholder to increase the holding of the stock while increasing the punishment and supervision of the management. More environmental information disclosure is the foundation of public participation and stakeholders will help the company to develop more effectively based on their own interests. Therefore, the impact of environmental information disclosure on companies may be reflected through more channels, such as financial markets, factor markets, and government regulation.

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Appendix A

Table A1. Definitions of variables.

Variable	Definition
Inefficiency (Biddle et al. 2006)	Investment inefficiency is absolute value of residuals we calculate with model (1)
Inefficiency (Richardson,2006)	Investment inefficiency is absolute value of residuals we calculate with model (2)
heavy	An indicator variable that takes on the value of 1 if the company is heavily polluting, and 0 otherwise
EID	An dummy variable that takes on the value of 1 after 2007, and 0 otherwise
EAR	An dummy variable that takes on the value of 1 if the company publish the annual stand-alone environmental information disclosure report this year, and 0 otherwise
EIR	An dummy variable that takes on the value of 1 if the company release interim reports on negative environmental information this year, and 0 otherwise
top1	The proportion of the largest shareholder
leverage	liability divided by total assets
growth	Sales growth rate
ROA	Return on total asset, equaling to the company's net profit divided by last period's total asset
lnage	The natural logarithm of listed year
mshare	the proportion of managerial ownership
fixedratio	Fixed assets divided by last period's total assets
financiallev	Sum of net income, income tax expense, finance charge and divided by net income + income tax expense
lnsalary	Natural logarithm of employee compensation
constraints	A proxy for financing constraints. Constraints = $(-0.737 * Size) + (0.043 * Size^2) - (0.040 * Age)$ by Hadlock and Pierce(2010)

Table A2. Distribution of EAR and EIR in various industries.

Industry	EAR (Environmental Annual Report)			EIR (Environmental Interim Report)		
	All	SH	SZ	All	SH	SZ
All the A share listed companies	3769	1967	1802	65	46	19
Heavy pollution industry	1689	846	843	58	41	17
Non heavy pollution industry	2080	1121	959	7	5	2
Extractive industry(B)	183	114	69	6	5	1
Food and beverage manufacturing(C0)	178	84	94	3	3	0
Textile, clothing and fur manufacturing(C1)	101	30	71	0	0	0
Paper and printing(C3)	80	36	44	2	1	1
Oil, chemicals, plastics, plastics(C4)	305	135	170	22	12	10
Metal and nonmetal manufacturing(C6)	407	182	225	9	7	2
Pharmaceutical and biopharmaceutical (C8)	211	101	110	7	6	1
Electricity, gas and water production (D)	224	164	60	9	7	2

Table A3. Placebo test for year 2007.

	(1)	(2)	(3)	(4)	(5)	(6)
2007 *Heavy	−0.0137 * (0.0069)	−0.0131 * (0.0067)	−0.0131 * (0.0067)	−0.0133 * (0.0067)	−0.0133 * (0.0068)	−0.0129 * (0.0067)
2008 *Heavy	−0.0049 (0.0036)					
2009 *Heavy		0.0017 (0.0028)				
2010 *Heavy			0.0018 (0.0023)			
2011 *Heavy				−0.0008 (0.0028)		
2012 *Heavy					−0.0008 (0.0031)	
2013 *Heavy						0.0033 (0.0021)
Constant	0.0743 *** (0.0080)	0.0744 *** (0.0080)	0.0744 *** (0.0080)	0.0744 *** (0.0080)	0.0744 *** (0.0080)	0.0743 *** (0.0080)
X	Yes	Yes	Yes	Yes	Yes	Yes
Observation	17,910	17,910	17,910	17,910	17,910	17,910
R-squared	0.0250	0.0249	0.0249	0.0249	0.0249	0.0250

Notes: Robust parentheses adjusted for firm-level clustering are reported in parentheses. *** $p < 0.01$, * $p < 0.1$.

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