The Impact of Environmental Information Disclosure on the Cost of Debt: Evidence From China

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Abstract
With the growing attention the public has paid to environmental issues, environmental disclosure is not only a vital means for firms to convey social responsibility but also an important information source for lending institutions to assess the credit risk of firms. Based on the data of listed companies in China from 2007 - 2016, this paper applies a two-way fixed effects model to determine the impact of environmental information disclosure on the cost of debt. It reveals that environmental information disclosure could decrease companies' cost of debt and that CEO duality and ownership concentration play vital roles in this relationship to some extent. After considering endogenous problems and testing the robustness, the conclusions still prove to be valid.

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Abstract: With the growing attention the public has paid to environmental issues, environmental disclosure is not only a vital means for firms to convey social responsibility but also an important information source for lending institutions to assess the credit risk of firms. Based on the data of listed companies in China from 2007 - 2016, this paper applies a two-way fixed effects model to determine the impact of environmental information disclosure on the cost of debt. It reveals that environmental information disclosure could decrease companies' cost of debt and that CEO duality and ownership concentration play vital roles in this relationship to some extent. After considering endogenous problems and testing the robustness, the conclusions still prove to be valid.

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Introduction

In the recent decades, governments, organizations, and corporate stakeholders have paid increasingly more attention to environmental protection and sustainable corporate development. Increasingly more stakeholders expected firms to conduct their business in a more transparent, ethical and responsible way, which led to the boom in corporate environmental information disclosure (EID) (Elias 2004). According to the United Nations (UN) Sustainable Stock Exchange (SSE) initiative, all large companies are expected to disclose their environmental performance by 2030.

By disclosing nonfinancial information, firms cater to investors' preferences, which improves the firms' evaluations from external stakeholders (Clarkson, Fang, Li, and Richardson 2010; Dhaliwal, Radhakrishnan, Tsang, and Yang 2012). Additionally, EID, as nonfinancial information, can be a key element used to measure a firm's reputation and evaluate a firm's default and reputational risk (Weber, Scholz, and Michalik 2010; Weber, Diaz, and Schwegler 2014). In turn, the capital market subsequently rewards high-level EID firms with lower required interest rates and lower costs of debt (Sharfman 2008). Thus, significant scholarly efforts have been made to assess corporate interest in and the relevance of EID (Belkaoui and Karpik 1989; Brooks and Oikonomou 2018; Ahmad and Tian 2019; Huang and Kung 2010; Aerts and Cormier 2009). The information possessed by the firm and the lender is not exactly equal. If a firm intentionally conceals some information that might cause an adverse impact, it will seriously harm the interests of the lender. High quality information disclosure can avoid the information asymmetry between creditors and firms and save the agency costs related to investigating the credit status of firms. The reduction of this cost will be directly reflected in the reduction of the debt financing costs of firms.

However, there are not many studies on the relationship between EID and the cost of debt (COD) (Erragragui 2018). As an index to measure the risk of a firm, the cost of debt is very significant for the future development of the firm because an associated funding gap may limit firm growth (Ferrando and Mulier 2015). In 2012, a great number of lending institutions signed the United Nations Environment Programme Statement by Banks on the Environment and Sustainable Development (UNEP 2012)). Since then, firms have sought to build brands by improving their EID level, and lending institutions began to realize the importance of EID in corporate reputation evaluation (Thompson and Cowton 2004； Zeidan, Boechat, and Fleury 2014). In this regard, some scholars started to assess the impact of EID on the COD (Stiglitz and Weiss 1981; Franco, Urcan, and Vasvari 2016; Fonseka, Rajapakse, and Richardson 2019).

Due to the different institutional factors in different countries, the legal consequences and penalties of EID may vary greatly from country to country (Van der Laan Smith, Adhikari, Tondkar, and Andrews 2010; Seetharaman, Gul, and Lynn 2002). Francis, Khurana, and Pereira (2005) document that differences in legal and financial systems across countries can affect observed disclosure levels. Most of the existing studies are based on developed countries, but there is little research on the topic in developing countries such as China. However, China is in the stage of economic upgrading, economic restructuring, and environmental governance (Hao et al. 2020). With increasing concerns about the environment, the government has established many regulations to decrease pollution from firms. These changes seriously affected the capital sources of Chinese listed firms.

This study analyses the impact of EID on the COD of Chinese listed firms from 2007 to 2016 and uncovers the aspects of the relationship between EID and financial market reactions. By employing a two-way

fixed effects model and the generalized method of moments (GMM), this study makes the following main contributions. First, relevant researches only consider the sub-industries (Luo et al., 2019), we are the very first paper that discusses the impact of EID on the COD while adopting the sample of all Chinese listed companies and employing a more objective means to measure the EID level. We provide evidence for firms that improving their level of environmental information disclosure not only contributes to a more humane and ethical external image but also reduces debt costs. Second, we provide insights into the heterogeneity of how EID influences financing costs. There are significant intergroup differences related to CEO duality and ownership concentration in the effect of EID on the COD. Third, we consider potential endogeneity and focus on the temporal dimension of the panel data.

The remainder of this paper is organized as follows: Section 2 presents a juristic background of Chinese EID policies. In section 3, we discuss the prior literature and develop the hypotheses. Section 4 is devoted to describing our methodology, the data, and the model. In section 5, we present the empirical results and discussions. In section 6, we conduct a robustness check. In the last section, we provide conclusions, implications, and future research directions.

Chinese EID legislation

Since the Club of Rome released its research report Limits to Growth in 1972, the disclosure of corporate environmental information has attracted increasingly more attention in the field of accounting. Disclosure is an effective and feasible means to enhance the transparency of environmental accounting information. Improving the EID level will reduce the information risk in the capital market, thus reducing the adverse selection and moral hazard in the capital market.

China is at a crucial stage of its economic development process. The demand for EID to support sustainable development is constantly increasing. The first regulation on EID from Chinese administrative departments was established in 2003. However, the regulation was too superficial to have a practical impact on firms' EID level. Thus, in 2007, the Ministry of Environmental Protection issued the Environmental Information Disclosure Measure (for Trial Implementation), which was implemented in 2008. This measure can be seen as a milestone in China's EID practice as it is the first normative and comprehensive departmental EID policy in China. In the same year, the Ministry of Environment Protection announced that Chinese listed firms should disclose environmental events that may affect the volatility of the stock market. Another major leap for Chinese EID legislation occurred in 2010. The Ministry of Environmental Protection issued a Guideline for the Environmental Information Disclosure of Listed Companies. This guideline specified that heavily polluting industries must publish environmental reports in their annual reports while non-polluting industries can provide it voluntarily. Moreover, it listed more detailed requirements for EID.

In summary, compared with developed countries, China's EID process started late, but it has developed fast. In China, the level of environmental information disclosure plays an increasingly important role in corporate debt financing costs.

Theoretical lens, literature review, and hypothesis development

Literature review

EID, as an important aspect of corporate social responsibility information disclosure, is not only required by laws and regulations but also required by the development of firms themselves. In addition, firms can reduce the regulatory burden through disclosure and ultimately increase their financial valuations (Aerts and Cormier 2009; Mathews 1997; Hahn and Kühnen 2013). Therefore, many scholars believe that EID has a positive impact on corporate financial performance (CFP) (Ahmad, Li, and Tian 2019; Porter and Linde 1995; Yin, Li, Ma, and Zhang 2019; Belkaoui and Karpik 1989; Deegan and Rankin 1996; Friedman 2007; Maltby 2004).

According to stakeholder theory, stockholders and managers can interact and create value (Freeman 1951). Stakeholders can contribute to the firm, while the firm meets the needs of the stakeholders (Wernerfelt 1984; Luo, Wang, Raithel, and Zheng 2015; Ioannou and Serafeim 2015). To some extent, stakeholders and the firm can be reciprocal. Existing studies have shown that information disclosure is conducive to stakeholders obtaining equal access to financial and nonfinancial information to reduce information asymmetry (Bushman 1991; Graham, Harvey, and Rajgopal 2005). Huang and Kung (2010) explored the impact of groups of external, internal, and intermediary stakeholder on firms' disclosure. And stakeholder groups' demands can significantly influence the level of environmental disclosure. Brammer and Pavelin (2006) asserted that the decisions related to environmental disclosure were driven by pressure from stakeholders.

A firm cannot survive and develop without a balanced social system. Legitimacy theory posits that organizations should ensure that they operate within the bounds and norms of their respective societies (Shocker and Sethi 1973; Brown and Deegan 1998). Thus, environmental disclosure can be regarded as an approach to expose information due to public pressure in the social environment (Milne and Patten 2002; Patten 1991). To legitimize corporate actions, corporate EID can be regarded as a reaction to environmental factors (Guthrie and Parker 1989). Cho and Patten (2007) suggested that firms with poorer environmental performance are expected to disclose more extensive offsetting environmental information in order to address the threats to their legitimacy. In line with this stream of literature, there is a positive link between EID and CFP.

However, some scholars believe that the reason why firms disclose their environmental information is to affect stakeholders' attitudes towards the firms' financial positions and prospects, instead of reducing environmental damage. Thus, these reports lack credibility and reliability (Cohen and Simnett 2014; Frost, Jones, Loftus, and Van Der Laan 2005). In addition, because of the high time and economic costs, managers are often not sure whether these reports achieve the expected outcomes (García-Sánchez, Hussain, Martínez-Ferrero, and Ruiz-Barbadillo 2019). In this case, firms are not able to maximize their profits such that EID may have a negative impact on CFP (Palmer, Oates, and Portney 1995; Hou 2019). Yang, Yao, and Li. (2020) found that there is a negative link between EID and CFP, while corporate internationalization has a positive moderating effect on this relationship.

Debt financing is one of the main external financing channels for firms, especially in China (Xu, Xu, and Yu 2019). It can affect the financial flexibility and operating risk of the firm and play a crucial role in emerging economies (Mitton 2007). According to pecking order theory, when firms need external financing, they should give priority to debt financing and then equity financing. Equity financing often sends the signal of overvaluation to outside investors, which has a negative impact on corporate financial performance (Wu, An, Wu, Tsai, and Yang 2020). Compared with equity financing, the cost of debt financing is relatively low, and the interest expense of debt capital is itemized before tax, which has the role of tax deduction. Thus, firms prefer debt financing when they need funds (Chen 2012).

In terms of loan decision-making, the environmental risks faced by lending institutions can be divided into three types. The most common one is indirect risk, which occurs when a firm default on loans as a result of poor financial consequences caused by environmental regulations. The second is direct risk, which occurs when the creditor takes over mortgage assets that have lost their merchant value due to environmental pollution (Boyer and Laffont 1997). For example, if land that has already been mortgaged for loans becomes contaminated as a result of polluting activities, the value of the land will decrease (Thompson and Cowton 2004). The third risk is the credit risk. The bad environmental behaviours of enterprises may lead to reputation losses, and managers need to detect the environmental factors of enterprises to reduce such risks. Therefore, credit risk is the most obvious way to influence creditors' decisions. First, disclosing environmental information helps banks and other creditors make reasonable assessments of the environmental risks, environmental investment, environmental governance performance and other information of firms to reduce adverse selection. Second, the regular disclosure of environmental indicators can motivate firms to take various environmental protection measures to reduce the emergence of environmental pollution problems, thus reducing the possibility of moral hazard.

Signalling theory posits that positive signals can help high-quality firms distinguish themselves from low-quality firms (Connelly, Certo, Ireland, and Reutzel 2011). Spence (1973) utilized the labour market to model the signalling function of education. He regarded education as an approach to convey unobservable characteristics and communicate with job candidates. During the practice of EID, borrowing firms usually have a superior information position while banks and other lending institutions have an inferior information position. Disclosing environmental information voluntarily can be regarded as a positive signal to creditors that they are confident enough to take full responsibility, especially when specific environmental issues occur. LO (2013) documented that in relationship lending, creditors and borrowers choose informal channels instead of public disclosure to reduce information asymmetry.

Prior studies have shown that firms can reduce the information asymmetry with external stakeholders and build good reputations through the active disclosure of environmental information. In this sense, firms with higher EID levels are more likely to obtain external debt financing. For example, Francis, Khurana, and Pereira (2005) employed a sample from 34 countries, and they found that the firms that are sensitive to external financing often have higher disclosure levels due to the need to have low costs of both debt and equity capital. Franco, Urcan, and Vasvari (2016) found that the bonds issued by firms with high-quality disclosures have lower yields compared to those of low-quality disclosure firms. Fonseka et al. (2019) found a statistically significant negative relationship between EID and the COD based on a sample of Chinese energy firms from 2008 to 2014. They also found that firms that use less polluting products can obtain a lower loan cost from banks.

Hypothesis development

Green credit, a financial policy implemented by the Chinese government in 2007, induced banks to consider the environmental factors of firms in the loan process (Zhang, Yang, and Bi 2011). In 2018, the green credit loan balance reached 8.23 trillion RMB in China, the impact of which was highly noticed both in practice and in academics (Xu and Li 2020). The Chinese government has issued a series of EID rules to urge Chinese firms to disclose their environmental information.

In theory, information asymmetry between lending institutions and firms can be reduced if lending institutions consider the environmental information of firms in their lending decision. According to stakeholder theory, by disclosing environmental information, firms can cater to the needs of stakeholders (Huang and Kung 2010). Reciprocally, stakeholders can create value for firms. In addition, EID can be conducive to increasing the valuation during the lending process by improving the reputation and reducing the default risk of firms (Weber, Diaz, and Schwegler 2014). Additionally, environmental information can be regarded as a positive signal for environmentally friendly firms to show their social responsibilities to the public. Empirically, Erragragui (2018) observed 214 firms in U.S. The results demonstrated that environmental concerns increased firms' debt financing costs, and environmental strengths reduced the cost of debt. China's EID policies are not very mandatory so that firms are relatively unwilling to disclose that negative environmental information voluntarily. Therefore, considered the reliability and integrity of data, we only focused on the impact of environmental strength information.

The above analysis leads to our hypothesis:

The environmental information disclosure level is negatively correlated with the cost of debt.

Data and methodology

Sample

To explore the relationship between the EID level and COD among listed firms in China, we obtain data from the CSMAR database, which provides the cost of debt and other financial data, and the CNRDS database, which includes the EID data.

The initial observation samples were screened according to the following four principles: (1) Chinese firms listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange from 2007 to 2016 were selected as the research samples as there were too much missing EID data before 2007; (2) because the regulatory system and statement structure of financial listed companies are quite different from those of other industries, we excluded the samples from the financial industry based on the general treatment methods of previous studies; (3) in consideration of the comparability and reliability of data, we followed most of existing studies and excluded special treatment (ST) samples. Because their financial information were relatively abnormal due to the poor management; and (4) the continuous variables were winsorized at the 1% level. Our final sample contains 5103 firm-year observations.

Measurement of variables

Cost of debt (COD)

With the development of the market economy, the credit market can not only make profits for lenders, such as banks and financial institutions, but also provide opportunities for firms' development. Debt financing is an important method of external financing for firms. According to the different debt repayment risks of firms, the rates of return on funds required by creditors are different.

The cost of debt can be an effective way to measure credit and risk. Following many previous authors (Kim, Simunic, Stein, and Yi 2011; Pittman and Fortin 2004; Francis, Khurana, and Pereira 2005, Gray, Koh, and Tong 2009), our proxy for the cost of debt (COD) is the interest expenses divided by the average total debt. A higher COD means that a firm has poor credit and high risk (Maaloul 2018).

Environmental information disclosure (EID)

There are mainly three ways to measure the level of information disclosure: the first is to directly use authoritative data. In theory, this approach is the most objective method to measure the EID level. However, there is no official, authoritative and integrated EID evaluation rating agency in China. The second is to measure

the quality of earnings. This method is widely used in financial information disclosure, but it is unfeasible for nonfinancial information, such as environmental information. The third way is content analysis, which establishes the information disclosure level measurement index system first and then grades the disclosures according to the index. There are two types of content analysis methods. The first is based on Clarkson, Li, Richardson, and Vasvari (2008) and Plumlee et al. (2008). They adopt an index set based on the environmental information-related indicators in the Global Reporting Initiative (GRI) guidelines. Then, they assign 1 if the information is reported and 0 otherwise. The other measurement is based on Wiseman (1982) and Cormier, Gordon, and Magnan (2004), which assigns 1 for a general disclosure, 2 for a specialized disclosure, and 3 for a quantitative description or monetization of information disclosure. In the existing studies, there are many articles adopting this method, but it is highly operable, so the results may be subjective to some extent.

Each of these measurements above, while they are somehow beneficial, has limitations. To increase the objectivity of the data, we did not add the scores according to the weight. However, we directly added the scores of six items to measure a firm's EID level instead. The six items are the following: a composite of three waste measures, which represent the policies, measures or technologies adopted by the company to reduce exhaust gas, waste water, waste residue and greenhouse gas emissions; circular economy, which refers to the company's policies and measures of using renewable energy or adopting a circular economy; energy saving, which refers to the company who has policies, measures or technologies to save energy; environmental certification, which represents companies with ISO 14001 certification; environmental recognition, which refers to a company who has received environmental recognition or other positive evaluations; and other advantages, which represent the other advantages in the corporate environment that are not covered in the above indicators. In this regard, the EID level can be calculated as follows:

$$EID_{\mathrm{i,t}} = \sum_{i=1}^{n} SEID_{i,j,t} \tag{1}$$

In the above equation, $EID_{i,t}$ represents the summed scores of the six environmental information items disclosed by firm i in year t; and $SEID_{i,j,t}$ represents the score of firm i on item j in year t, where j =1, 2, 3, …,6.

Control variables

Based on prior studies, we adopt fifteen control variables that may be significantly related to the relationship between EID and COD. These variables are defined in Table 1.

Table 1. Definition of variables

Variable name	Variable symbol	Definitions of variables name
Cost of debt (%)	cod1	[interest expense/(short-term debt+ long-term debt)]*100%
EID level	EID	the summed scores of the six environmental information items disclosed by firms
Growth rate of earnings per share	grow	（eps of this quarter - eps of last quarter）/eps of the last quarter
CEO duality	duality	The dummy variable, i.e., 1 for firms whose CEO is also the COB and 0 otherwise
Composite tax rate	tax	(Business tariff and annex+ Income tax expense)/Gross revenues
Financial pressure	ctdratio	（current asset- current liabilities）/total borrowing
Financing constraints	constraints	(-0.737*Size) + (0.043*Size^2) - (0.040*Age) from Hadlock and Pierce (2010)
Analyst forecast PB	fpb	Analyst forecast price /book value
Leverage	lev	Total assets /Total liabilities

Firm size	size	Firm size
Return on assets	roa	Net profit /total assets
Capital receivable ratio	capital	（notes receivable +net account receivable） / total assets
Operating liability ratio	liability	(Current liabilities-short-term borrowings-non-current liabilities due within one year-trading financial liabilities-derivative financial liabilities) /Total liabilities
Shareholding rate of executives	mshare5	The sum of the executive shareholdings
Analyst forecast BPS	fbps	Analyst forecast equity/capital
Executives	executive	The number of executives
Largest holder rate	largest	The sum of the percentages of the largest shareholders (%)

Models and analytical techniques

The goal of this paper is to examine the impact of EID on the corporate cost of debt and how analysts' forecasts affect it. The traditional fixed effects model only considers individual effects and does not consider the residual correlations of different companies in different periods. To avoid model selection bias, we adopt a two-way fixed effects model to explore the relationship between EID and the COD. In addition, considering the endogeneity problem, we use lagged values of the control variables. We constructed the following model:

$$COD_{i,t} = \beta_0 + \beta_1 EID_{i,t} + \sum \tau_j * X_{j,i,t-1} + \mu_i + \varphi_t + \varepsilon_{i,t} \quad (2)$$

where subscript i represents different listed companies, t represents time variables, COD represents the cost of debt, EID represents the environmental information disclosure level of firm i, X is the matrix vector of the control variables, μ represents a firm-specific effect to control for unobserved heterogeneity, φ represents the control for the year fixed effect, and ε is the stochastic disturbance term.

Result

Descriptive analyses

Table 2. Descriptive statistics of variables

Variable	N	Mean	Sd	Min	P50	Max
cod1	4924	0.220	0.330	0	0.0800	1.640
EID	5103	2.180	1.350	0	2	5
grow	4792	0.0800	5.370	-28.42	-0.0600	25.33
duality	5103	0.170	0.380	0	0	1
tax	5103	0.0400	0.0500	-0.0100	0.0200	0.220
ctdratio	4616	11.56	50.67	-2.440	0.790	420.6
constraints	5103	4.990	1.740	2.120	4.670	10.53

fpb	4821	3.130	2.270	0.630	2.480	12.79
lev	5103	0.490	0.200	0.0600	0.510	0.870
size	5103	22.91	1.430	20.18	22.77	26.95
roa	5103	0.0500	0.0500	-0.110	0.0400	0.210
capital	5103	0.120	0.110	0	0.0900	0.490
liability	5103	0.530	0.260	0.0700	0.500	1
mshare5	4853	0.0300	0.0900	0	0	0.510
fbps	4919	5.140	2.790	1.380	4.470	15.40
executive	5092	7.300	2.820	3	7	18
largesthol~e	5103	38.67	16.12	8.120	38.76	77.07

Table 2 reports the descriptive statistics of the primary variables. The average of EID is 2.18, and the median is 2. This indicates that the overall level of EID of Chinese listed firms is still not high. The maximum EID is 5 and the minimum is 0, which means that the level of disclosure varies among firms and year.

Table 3. Basic status of EID

Year	**EID**						
	0	**1**	**2**	**3**	**4**	**5**	**Total**
2007	8	11	6	9	2	1	37
2008	44	76	94	89	36	8	347
2009	53	101	113	99	46	15	427
2010	65	95	128	99	66	36	489
2011	47	120	142	139	70	21	539
2012	68	120	154	152	72	31	597
2013	67	142	166	136	79	32	622
2014	62	114	177	167	112	21	653
2015	104	151	184	155	70	21	685
2016	93	149	181	130	102	52	707
Total	611	1079	1345	1175	655	238	5103

Table 3 shows the numbers and the EID levels of Chinese listed firms from 2007 to 2016. The table shows that the overall environmental information disclosure level of listed firms in China is still relatively low, and the disclosure content is insufficient. More specifically, the number of firms that made EIDs increased significantly in 2009 and 2008, which may be due to the Environmental Information Disclosure Measure (for Trial Implementation) and the Guidelines for the Environmental Information Disclosure of Listed Companies of the Shanghai Stock Exchange. This indicates that the EID level of firms is greatly influenced by policies.

The impact of EID on the cost of debt

Table 4. Benchmark regression result

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	FE	**RE**	**POLS**	**POLS_IND**	**Heckman 2-Step Correction**	
EID	-0.009**	-0.013***	-0.019***	-0.016***	-0.010**	-0.013**
	(0.004)	(0.004)	(0.006)	(0.006)	(0.005)	(0.005)
Inverse Mills Ratio						0.248**
						(0.124)
Constant	-6.492**	-1.802**	-1.436	-1.208	-7.519	-11.202***
	(2.525)	(0.880)	(0.942)	(0.992)	(4.742)	(3.729)
Control	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	NO	NO	NO	YES	NO	NO
Observations	3,305	3,305	3,305	3,305	2,665	2,665
R-squared	0.123		0.186	0.206	0.109	0.110
Number of stocks	691	691			615	615

Note. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively; all control variables and the constant term are included but reported.

To provide initial empirical evidence on the EID-COD relationship, we show the benchmark regression results in Table 4. Model 1, Model 2, Model 3, and Model 4 are the results based on the two-way fixed effect model, random effect model, pooled OLS, and pooled OLS after controlling for the industries, respectively. We find that EID is negative and significant in explaining the COD (β_1=-0.009, $p < 0.05$). Then, we examine the primary evidence on this association. We find that the result is robust to the model specifications, which supports our hypothesis 1 that EID has a negative and significant impact on the COD. Most China firms can choose not to disclose environmental information. Firms disclosing this information likely are those that their profits are not significantly affected by EID. In consideration of this selection bias, we adopt Heckman two-step correction in Model 5 and Model 6. In the first step, we add the dummy of 'whether the firm has COD' into the Model 5, and estimate the Inverse Mills Ratio (the Mills ratio). In the second step, the Mills ratio is added to the model as a control variable to control the possible selection bias in the primary model. The Mills ratio is significant at 5% level, which indicates that there is selection bias. The EID is still negative and significant in explaining the COD (β_1=-0.010, $p < 0.05$), which is very close to the coefficients obtained without Heckman's two-step method. This suggests that lending institutions conduct credit risk analysis, which includes considering EID. If firms have better EID levels, lending institutions will reduce their financing costs.

This result is consistent with prior studies (Goss and Roberts 2011; Ge and Liu 2015; Hasan, Hoi, Wu, and Zhang 2017; Eliwa, Aboud, and Saleh 2019). First, firms can convey positive signals to fulfil stakeholders' demands, which can avoid the information asymmetry between creditors and firms and increase the understanding and support of the public. Second, lending institutions may incorporate firms' EID in their lending process to avoid default risk and reputational risk (Weber, Diaz, and Schwegler 2014).

Heterogeneity analysis

Table 5. Heterogeneity assessment

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	CEO duality	**CEO separation**	**Ownership concentration**	**Ownership dispersion**	**High disclosure**	**Low disclosure**
EID	-0.006	-0.009**	-0.012*	-0.007	-0.010	-0.019*
	(0.017)	(0.005)	(0.006)	(0.006)	(0.010)	(0.011)
Constant	10.525	-6.593**	-7.935**	-6.995*	1.017	-13.445***
	(9.430)	(2.702)	(3.808)	(3.844)	(4.190)	(4.012)
Control	YES	YES	YES	YES	YES	YES
T	YES	YES	YES	YES	YES	YES
Observations	518	2,787	1,659	1,646	1,447	1,858
R-squared	0.183	0.123	0.126	0.139	0.159	0.126
Number of stocks	204	609	377	392	457	570

Note. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively; all control variables and the constant term are included but reported.

Many prior studies have investigated the link between CEO duality and corporate disclosure (Samaha, Khlif, and Hussainey 2015; Lagasio and Cucari 2019; Cucari, Esposito De Falco, and Orlando. 2018). CEO duality refers to the situation where the CEO and the chairperson are the same person simultaneously (Rechner and Dalton 1991). If the CEO and the chairman of the board (COB) are the same person, that person will have great power, such that the CEO can erode the board's power. Many scholars have found that CEO duality may be associated with disclosure levels and corporate governance quality (Elsayed 2007; Cheng and Courtenay 2006; Giannarakis 2014; Jizi 2017). Based on this, we divided the samples into CEO duality and CEO **separation** groups (the situation where the CEO and COB are the same person, and the opposite situation). The regression results are shown in Table 5, Model 1 and Model 2, respectively. The results show that the EID level in the firms with CEO **separation** is significantly negative at the 5% level, which indicates that EID can significantly reduce corporate debt financing costs. However, if the CEO and COB are the same person, the relationship between EID and the COD is not statistically significant. A possible reason is that powerful CEOs may seek to maximize their private interests at the expense of the shareholders' interests. Therefore, the information asymmetry between the company and the lenders may be exacerbated when CEO and COB are the same person.

Agency theory can be the most prominent theory to address the topics related to corporate governance and corporate social responsibilities (Pucheta-Martínez, and Gallego-Álvarez 2018; Zaid, Abuhijleh, and Pucheta-Martínez 2020). The ownership concentration is of great importance in reducing the principal-agent problem (Jensen 1993). Large shareholders have advantages in imposing their interests and influencing firms through the alignment or direct monitoring of management (La Porta, Lopez-De-Silanes, and Shleifer 1999).

Considering the heterogeneity of the largest shareholders, we add a further category from the field of corporate governance. As the average of the percentages of the largest shareholders in China is 38.670%, we divide our sample into two groups. The sample observations that the percentages of the largest shareholders are larger than 38.670% are in the concentrated ownership group (Table 5, Model 3), and those below that value are in the dispersed ownership group (Table 5, Model 4). The regression results imply that the EID of the large shareholder group is negatively correlated with corporate COD. However, EID has no statistically significant influence on the COD in the low shareholder group. A possible reason for the results above is that larger shareholders have a stronger incentive to monitor directors and managers so that they can solve the top management-owners' behaviours (Zaid, Abuhijleh, and Pucheta-Martínez 2020). The higher the shareholding

ratio of the largest shareholders is, the stronger the control of the major shareholders over the board of directors. This phenomenon is especially obvious in the capital market with equal rights per share, especially in China.

Hence, in the firms where the largest shareholder holds a greater percentage of the shares, the largest shareholder is able to control the CEO and other directors on the board such that the largest shareholder himself will receive less supervision. In this case, the information asymmetry can be more serious and its risks may be more severe; thus, debt financing costs will be higher. Conversely, firms with dispersed ownership may not be able to supervise managers efficiently (Pucheta-Martínez, and Gallego-Álvarez 2018). It is assumed that managers are more responsible than owners, such that they prefer to disclose their information (Khan et al. 2013)

Different disclosure levels may have different correlations with corporate risk-taking (Zhou, Liu, and Chen 2018). To obtain a better insight into this issue, we split the sample into two groups: 'high EID level firms' (high disclosure hereafter) and 'low EID level firms' (low disclosure hereafter), respectively (Table 5, Model 5 and Model 6). Table 6 displays the descriptive statistics of the high disclosure and low disclosure groups. We find that 59.47% of firms in China are under the average level of EID. The results based on the two-way fixed effects model in columns (5) and (6) in Table 5 indicate that the EID level of the low disclosure group is significantly negatively correlated with the COD while there is no statistically significant relationship in the high disclosure group. There are mainly two reasons for why it makes sense in China. First, because of the law of diminishing marginal utility, the firms with high level of EID may reduce less COD than those with low EID level when improving EID level. Second, disclosing environmental information is not widespread in China. Some financial institutions may not be particularly aware of the importance of EID. Therefore, firms with high-level EID may have no advantage compared with firms with low-level EID.

Table 6. Descriptive statistics of different levels

	Freq.	**Percent**	**Cum.**
Low disclosure	3,035	59.47	59.47
High disclosure	2,068	40.53	100.00
Total	5,103	100.00	

Robustness check

Alternative independent variables

Table 7. The impact of EID on COD

	Model 1	**Model 2**	**Model 3**	**Model 4**
	FE	**RE**	**POLS**	**POLS_IND**
env	-0.051**	-0.056***	-0.048*	-0.031
	(0.020)	(0.019)	(0.026)	(0.025)
Constant	-6.586***	-1.766**	-1.299	-1.081
	(2.523)	(0.885)	(0.952)	(0.996)
Control	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	NO	NO	NO	YES
Observations	3,305	3,305	3,305	3,305
R-squared	0.124		0.182	0.203

Number of stocks	691	691

Note. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively; all control variables and the constant term are included but reported.

To verify whether the EID level can alleviate financing costs, we introduce a dummy variable ENV, which equals 1 for firms who disclose their environmental information and 0 otherwise. Table 7 shows the regression results between ENV and COD. The estimated coefficient of ENV is still statistically significant at the5% level based on the two-way fixed effects model. Compared to those firms who do not disclose environmental information, those who do disclose their environmental information often have lower cost of debts. This result adequately supports the aforementioned results in Table 4.

Alternative dependent variables

Table8. The impact of the EID level on the COD

	Model 1	**Model 2**	**Model 3**	**Model 4**
	FE	**RE**	**POLS**	**POLS_IND**
EID	-0.011**	-0.015***	-0.022***	-0.019***
	(0.005)	(0.004)	(0.007)	(0.006)
Constant	-8.353***	-2.143**	-1.533	-1.307
	(2.825)	(0.982)	(1.018)	(1.072)
Control	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	NO	NO	NO	YES
Observations	3,305	3,305	3,305	3,305
R-squared	0.106		0.173	0.192
Number of stocks	691	691		

Note. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively; all control variables and the constant term are included but reported.

To verify the robustness of the empirical testing, we change the calculation method of the COD. The measurement is changed from the interest expenses divided by the average of short- and long-term debts to interest expenses divided by the average of the total debts from this term and the previous term (Pittman and Fortin 2004). These results are shown in Table 8, which illustrates that there is a negative and significant link between the EID level and the COD. The results are consistent with the aforementioned results in Table 4, which implies that our results are robust.

GMM

Table 9. The benchmark results based on the GMM

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
	DIFF_GMM1	**DIFF_GMM**	**DIFF_GMM2_**	**SYS_GMM**	**SYS_GMM**	**SYS_GMM_o**

		2	or	1	2	r
EID	-0.070**	-0.085***	-0.063**	-0.120***	-0.077**	-0.078**
	(0.033)	(0.032)	(0.031)	(0.036)	(0.038)	(0.035)
Constant				0.000	7.825	-2.133
				(0.000)	(11.138)	(3.737)
Control	YES	YES	YES	YES	YES	YES
T	YES	YES	YES	YES	YES	YES
AR (1) test p	0.000	0.000	0.000	0.000	0.000	0.000
AR (2) test p	0.820	0.944	0.109	0.739	0.272	0.272
Sargan	0.129	0.058	0.610	0.000	0.000	0.000
Hansen	0.605	0.261	0.853	0.125	0.111	0.121
Observations	1,470	1,464	1,450	1,529	2,076	2,127
Number of stocks	452	451	442	476	536	541

Note. *, **, and *** represent the 10%, 5%, and 1% significance levels, respectively; all control variables and the constant term are included but reported; in the dynamic GMM estimation, AR(1) and AR(2) respectively refer to the first-order and second-order serial correlation in the first differenced residuals. The Hansen test and the Sargan test are used to examine whether the instrumental variables are overidentified.

As in related studies, potential endogeneity may affect the interpretation of the casual relationship between EID and the COD (Erragragui 2018). In our context, endogeneity problems may arise from three sources. The first source is omitted variables that are correlated with EID and the COD. There may be some potentially correlated variables that we have not included with the control variables of the initial model. In addition, measurement error is often unavoidable (Fornell and Larcker 1981). Additionally, according to Waddock and Graves (1997), our study may be affected by the direction of the causation, as it is impossible that firms' EID activities cannot be completely conducted without considering their debt financing costs.

To address these concerns, we implement the GMM estimator. We adopt the difference GMM developed by Arellano and Bond (1991) in the first three columns of Table 9 and the system GMM developed by Blundell and Bond (1998). Columns 1 and 4 display the results based on the one-step estimator, columns 2 and 5 display the results based on the two-step estimator, and columns 3 and 6 display the results based on the orthogonal deviations transform. In addition, the results of specification tests for instruments verify that instrumental variables are adequately proper. In this regard, EID still has a negative and significant impact on the COD, which indicates that better EID can decrease the COD, ceteris paribus.

Conclusion

Intensified by the current severe environmental problems and 2008/2009 financial crisis, the public began to pay continuous attention to the corporate EID level and discuss the frequently related incidents. Additionally, a growing number of firms sought to strengthen their communication with stakeholders by disclosing their environmental information. For a sample of Chinese listed firms from 2007 to 2016, we adopted the two-way fixed effects model to examine the relationship between EID and the COD, and our findings reveal the following:

First, this research shows that the EID level reduces the COD for reporting firms. First, improving the level of environmental information is conducive to reducing the information asymmetry with lending institutions and reducing the information costs of lending institutions. Second, improving the EID level is conducive to

improving the reputation of firms, thus reducing the reputation risk and default risk of firms. In this regard, reporting firms can obtain lower debt financing costs.

Second, we document that the correlation above is statistically significant in the firms where the CEO and the chairperson is the same person, which implies that a powerful CEO may promote transparency. In addition, the impact of the EID level on corporate debt financing costs is also significantly negative in the firms where the percentages of shares held by the largest shareholders are greater than the average percentage in China. Additionally, we find that the relationship between EID and the COD can be affected by firms with different EID levels.

Our research makes the following three contributions. First, our research adopts open data combined with objective measurements. Firms' EID activities help the public understand the environmental responsibilities the firms have taken in depth and play a role in urging firms to better fulfil their environmental responsibilities to enhance their overall value. We advocate that EID can be a transmitting signal between firms and the capital market. In this sense, stakeholders can avoid the risks caused by information asymmetry, which will result in lower financing costs. Our research extends the limited literature on the relationship between EID and debt financing costs. In addition, we fully discuss the significant heterogeneity in different groups related to CEO duality and ownership concentration. The impact of the EID level on the COD is more significant in the firms where the CEO and COB are the same person, with a high shareholding ratio of the largest shareholders and with a low disclosure level.

The above findings have several policy implications. First, our results can help boost the confidence of firms to disclose their environmental information. Disclosing environmental information not only benefits the sustainable development of the environment but also benefits firms themselves. Firms can alleviate the information asymmetry with creditors through high-level EID to intensify their own reputation and alleviate the risk of default, thus reducing the debt financing costs of firms.

Second, our study encourages investors and other stakeholders in the capital market to pay attention to firms' EID levels. Compared with financial information or other nonfinancial information, environmental information is more professional and hidden, which makes creditors experience an information disadvantage.

Third, our results have important significance for government departments and other regulatory bodies. Environmental issues have strong externalities and are typical public goods. Moral constraints may not be enough for firms to consciously fulfil their environmental responsibilities. Only by linking corporate interests with specific environmental protection activities will they effectively fulfil their environmental responsibilities. An advanced and integrated EID system can be an effective method to urge firms to improve their level of EID and enhance the impact of EID on the capital market.

While we show that EID may mitigate the COD, our study is not free of limitations, similar to any other empirical study. Future researchers could more closely examine companies in different industries. In this study, we use Chinese listed firms as our sample. However, the level of EID in different industries may vary greatly due to policy requirements, industry characteristics and other reasons. These may include environmentally sensitive industries or industries somehow responsible for their environmental impacts, such as the real estate industry (Sharifi and Murayama 2013; Fonseka, Tian, and Al Farooque 2019), heavy pollution industries (Luo, Guo, Zhong, and Wang 2019), and others.

In addition, since the actual loan interest rate is not disclosed in the annual reports of Chinese listed companies, this paper adopts the method that the cost of debt is measured by interest expenses divided by the total debts, which may deviate from the actual financing costs.

Moreover, our sample consists only of listed firms in China due to data constraints. However, firms that are not listed on stock exchanges, such as small- and medium-sized firms, are more likely to depend on bank loans (Kordsachia 2020). Only few existing studies have focused on these firms. It would be interesting to explore them in future studies.

Authors' contributions

Y YL proposed the direction of the research and the framework of the manuscript, and provided the data sources. W J integrated and analyzed the data, used the model for accounting, screened the results and was a major contributor in writing the manuscript. L Y set the pace and oversaw the process. All authors read and approved the final manuscript.

Finding

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Availability of data and materials

The data source: China Stock Market & Accounting Research Database (https://www.gtarsc.com/)

Declarations

Ethics approval

Ethical approval was not required for analysis of data in this study.

Consent to participate and publish

We give consent to publish our work and is jointly contributed by all authors.

Competing interests

The authors declare that they have no competing interests.

Appendix A

Table A. Correlation coefficients

Variables	cod1	EID	grow	duality	tax	ctdratio	constraints	fpb	lev	size	roa
cod1	1.000										
EID	0.045***	1.000									
grow	-0.010	-0.021	1.000								
duality	0.022	-0.061***	-0.012	1.000							
tax	0.031**	-0.055***	0.057***	-0.021	1.000						
ctdratio	-0.090***	-0.031**	0.002	0.006	0.014	1.000					
constraints	0.206***	0.281***	0.000	-0.109***	0.126***	-0.089***	1.000				
fpb	-0.167***	-0.195***	0.030**	0.126***	-0.034**	0.100***	-0.404***	1.000			
lev	0.148***	0.124***	0.001	-0.123***	-0.039***	-0.254***	0.488***	-0.210***	1.000		
size	0.230***	0.286***	0.002	-0.122***	0.138***	-0.083***	0.983***	-0.419***	0.515***	1.000	
roa	-0.127***	-0.040***	0.035**	0.094***	0.259***	0.209***	-0.089***	0.275***	-0.456***	-0.115***	1.000
capital	-0.164***	-0.005	0.009	0.080***	-0.350***	0.113***	-0.137***	0.173***	-0.063***	-0.143***	0.110***
liability	-0.360***	-0.130***	0.025*	0.042***	0.007	0.346***	-0.167***	0.229***	-0.335***	-0.184***	0.354***
mshare5	-0.038***	-0.147***	0.000	0.397***	-0.071***	0.043***	-0.214***	0.231***	-0.242***	-0.268***	0.146***
fbps	0.018	0.123***	0.025*	0.026*	0.063***	0.134***	0.300***	-0.234***	-0.031**	0.305***	0.191***
executive	0.035**	0.168***	-0.004	0.012	0.000	-0.024*	0.291***	-0.085***	0.161***	0.285***	0.021
largestholderrate	0.053***	0.115***	-0.009	-0.099***	0.108***	0.020	0.305***	-0.100***	0.072***	0.282***	0.035**

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