

A U-shaped Relationship Between Corporate Environmental Information Disclosure and Risk Exposure in Stock Market- Empirical Evidence from Cross-sectional Data in Thermal Electricity and Metal Industries.

QUANQI LIU

Shenzhen Graduate School
Harbin Institute of Technology
Shenzhen University Town in Shenzhen city
CHINA
Quanqilau_2002@126.com

KAI CHANG

School of Finance
Zhejiang University of Finance & Economics
High education park, Xiasha district, in Hangzhou city
CHINA
kchang16@zufe.edu.cn

Abstract: - Environmental information disclosure exhibits an increasing trend, and different corporate exhibit greater periodic-divergence on the quality of disclosing environmental information from 2008 to 2013. We investigate a significant causality association between environmental information disclosure, stock price risk and idiosyncratic risk exposure using Pedroni and Fisher test methodology in panel data. Our results hold the significant association between environmental information disclosure, stock price risk and idiosyncratic risk exposure exhibits a U-shaped relationship, the effect of environmental information disclosure on stock price risk and idiosyncratic risk exposure exhibits a significantly periodic-divergence from 2008 to 2013.

Key-Words: - environmental information disclosure; Fama-French model; idiosyncratic risk; risk exposure; panel data

1 Introduction

Corporate environmental information disclosure and environmental responsibility problems has become an ever-increasing hot topic in recent years. More and more stakeholders such as environmental regulators, investors and customers pay much attention to corporate environmental performance and risk exposure and other financial information. Market investors focus on corporate environmental information disclosure with an increase of public environmental awareness, and then environmental performance begin to have a significant impact on corporate environmental strategy and investment decisions. Fatal environmental pollution accidents not only seriously damage corporate social image and reputation, stock market make strongly negative reactions due to corporate environmental pollution accidents, but also fatal pollution accidents cause a series of fine, economic compensation and lawsuits etc, environmental information disclosure may

affect good market expectation for corporation's future profits. Corporate actively seek synchronous communication with stakeholders through social responsibility reports and sustainable environment reports, and then keep synchronous disclosure with cost, quality and financial performance.

The relationship among corporate financial performance, risk exposure and environmental performance has been controversy, and different scholars hold three opinions: significantly positive correlation and negative correlation and non-correlation. Better environmental information disclosure enable improve corporate operation efficiency and raise stakeholders' market expectation, and then increase corporate market values [1-2]. Corporate size, industrial type, profitability, Tobin's Q value, ownership structure and marketization have obvious effects on environmental performance, which improve corporate social image and reputation[3-6].

Environmentalists believe that environmental information disclosure and environment-protection activities attract more institutional investors and strengthen investors preferences, and reduce the related environmental cost such as incline waste disposal costs, assets depreciation costs in environmental protection practices and political risk costs etc, and then improve corporate financial performance and meet stakeholders' interests demand [7-12]. Resource and environment efficiency theory argues that strict environmental regulation and environmental information disclosure system stimulate environment-protection technology progress and environmental management innovation, cost reduction and continual investment enhance investors market expectation, create more and more market opportunities, and then improve corporate future earnings expectations.

The traditional classical theory believes that environmental regulation and environmental performance are mutually contradictory. Environmental strategy and environment-protection practices increase environmental protection investment and purchase the environmental facility, increase assets depreciation costs, recovery cost of ecological environment etc, and then reduce market competitive opportunities and increase corporate financial burdens. Information disclosure of waste treatment has no positive effect on corporate financial performance, while information disclosure of greenhouse gas has significant impact on financial performance [13-14]. Stringent environmental regulation raise corporate environment-related operation cost and damage shareholder value maximization, thereby environmental expenditure information disclosure reduce corporate financial performance [15-16]. Information disclosure in corporate environmental responsibility has a negative impact on returns of asset and Tobin's Q value, waste disposal information disclosure enable corporate negative market expectation [17-18]. In brief, environmental information disclosure, environmental investment and stringent environmental regulation may have negative impacts on corporate financial performance.

The relationship between environmental performance and risk exposure are also focused on in recent years. Corporate risk exposure induced by environmental information disclosure has three problems: expected returns change (financial performance affected by environmental performance), environment idiosyncratic risk (environmental information asymmetry and liquidity problems), and expected loss caused by

environmental pollution accidents. If the stakeholders are naïve or optimistic, corporate may disclose fuzzy environmental information, however corporate tend to disclose more environmental information [19]. Risk-averse environmental regulators may produce commercial moral confusion, and lead to adverse consequences of environmental risk prevention [20]. Environmental information disclosure and risk assessment are of key elements for bank analyst to estimate corporate market value and financial risks, meanwhile directly affect bank lending-decisions [21]. Environmental risk assessment is important for corporate decision-makers, environmentalists believe that environmental information disclosure has a negative effect on corporate financial performance and environmental risk [22-23]. Compared with listed electric firms who own higher non-state ownership, listed firms owned higher state ownership tend to disclose more environmental information in an active and voluntary behaviour, Listed firms with an increase of ownership concentration and financial leverage voluntarily disclose more environmental information, which is helpful for stakeholders to reducing environmental and financial risk [24]. Corporate with greater institutional owners-owned ownership and ownership concentration should voluntarily disclose more environmental information, should communicate with institutional owners and minority controlling shareholders firms' environmental achievements and then strengthen their investment confidence and improve shareholders' interests [25]. GDP per population and carbon emission intensity have significantly inverted U-shape EKC effect on carbon emission quantity at the confidence of 95% level from 2006 to 2015, accordingly optimizing energy-consuming structure and reducing energy intensity are helpful to incline carbon emission intensity and total quantity growth of carbon emission in eleventh-five and twelfth-five periods under the constraint of energy-saving and emission-reduction policy [26]. Neri (2012) discuss a computational simulation technique based on agent based modeling and learning to closely approximate the SP500 and DJIA indexes over many periods and under several experimental set ups [27]. Neri(2014) present in the following the state of the art for computational techniques for financial applications both from the methodological and applicative points of view [28]. Neri (2014) report a variety of algorithmic approaches (genetic algorithms, svm, etc.) and applicative domains (nuclear power plants, rotating

machinery, etc.) to illustrate the extension of the advanced control methods research area [29]. Therefore environmental information disclosure is the significant variable for corporate operation decisions and bank loan decisions, and environmental performance has a negative impact on corporate financial performance.

The correlation between environmental information disclosure and risk exposure is of significant problem to introduce environment-protection strategy. From the above empirical results, their relationship is ignored. Environmental risk exposure reduction may increase corporate market value, grasping the correlation between environmental information disclosure and risk exposure is important for environmental regulators, corporate managers and market investors. This paper has three major contributions. Firstly, our empirical results show that environmental information disclosure has significant causality with stock price and idiosyncratic risk exposure. Secondly, environmental information disclosure has a significant U-shaped relationship with corporate stock price risk and idiosyncratic risk. Thirdly, environmental information disclosure exhibits a significantly periodic-divergent effect on stock price risk and idiosyncratic risk exposure from 2008 to 2013.

The rest of this paper is organized as follow. Theoretical analysis and hypothesis development are constructed in section 2. Section 3 presents research methodology. Section 4 discussed sample data source and environmental information disclosure. Section 5 put forwards empirical results and discussions. And the conclusions and policy implications are given in Section 6.

2 Theoretical analysis and hypothesis development

Voluntarily disclosing more environmental information has two prerequisites: Firstly, corporate have enough economic capacity to carry out environmental protection practices and recognize the potential consequences induced by environmental pollution accidents. Secondly, environmental information disclosure can produce reasonable returns, and take into account related costs paid by environmental information disclosure and risk exposure problems in stock market.

The effect of environmental information disclosure on corporate risk exposure may have two contradictory theories. Serious environmental incidents usually damage ecological environment

and residents' health, accompanied with a series of environmental problems such as economic compensation, lawsuits and ecological environment restoration etc. Meanwhile, environmental events may severely damage corporate image and reputation, affect corporate future earnings expectation, and increase corporate future financial burdens, thereby environmental accidents has a negative impact on corporate market value and may cause more potential risk exposure. Heavy economic compensation and long-run environmental lawsuits lead directly to corporate cash outflow and profits loss, media exposure and negative reports induce unfavorable market shock in stock market, and reduce market competitive opportunities and increase stock price risk exposure. Traditional theory argue that voluntarily disclosing more environmental information may increase environment-protection inputs and corporate operating costs, damage current production capacity and reduce corporate market competitive opportunities, and then enhance corporate financial risks and stock market risks exposure. Supportive theory believe that corporate environmental performance improvement raise related costs in short-term, proficient environment-protection skills help corporate incline raw materials consumption and create more incomes induced by energy efficiency and production efficiency. Green products and business development create more market opportunities, environmental management improvement may avoid environmental regulations and lawsuits extended by environmental accidents, thereby those favorable information enhance the stability of future cash flow, and reduce stock market risk exposure.

Perceived environmental risk exposure believes that environmental management failure and crisis induced by unskilled environment-protection practices or policy causes the reduction of corporate financial performance [22]. The beginning of environmental protection strategy, corporate have to undertake heavy financial burdens and greater operation risk without mastering mature environmental regulation and management standards. Firstly, more environmental information disclosure indicates that corporate need carry out a good many environmental management activities and higher environmental standards. Corporate have to increase research and development inputs of environment-protection technology, and purchase a large number environment-protection facilities, spend huge capitals to purify ecological environment. Corporate may increase waste disposal costs, assets depreciation cost, environment

monitoring cost and information-disclosing cost in short run, accordingly stakeholders worry that stringent environmental regulation cause greater financial risks. Secondly, unfamiliar environment-protection skills evoke potential environmental accidents or crisis, and heavy financial burdens expose more financial risk and debt default risk [30]. Stakeholders focus on how to convert more environmental information disclosure into favorable financial benefits and risk exposure reduction. We propose the two hypothesis.

Hypothesis 1. Environmental information disclosure has a significant causality with risk exposure.

Hypothesis 2. Environmental information disclosure has a significantly negative impact on risk exposure.

Corporate gradually accumulate rich experiences and master familiar skills in environmental protection with an continuity of environmental protection implement, improve environmental management strategy, and then environmental inputs achieve reasonable benefits in the long term. Excellent environmental performance improve financial performance, enhance better market expectation of corporate future earning, and then decrease corporate risk exposure. Firstly, sustained environmental inputs can update environment-protection technology and improve production process, these environmental protection skills and experiences promote corporate energy-saving and emission-reduction activities, improve energy usage efficiency and production efficiency, reduce raw material consumption, and then resource recycling and environmental management innovation may create greater financial benefits. Secondly, society political pressure theory argue that greater environmental responsibility can promote green environmental protection practices, improve corporate social image, reputation and cognitive ability of risk management, expand green products and brand strategy, and then incline corporate risk exposure. Thirdly, corporate have good will to communicate with stakeholders, more environmental information disclosure may push stakeholders forward joining in corporate environmental management activities, and reducing political risk and market risk in environmental protection strategy. Reducing greenhouse gas emission and sewage leakage can make corporate incline stringent environmental regulation and economic fines. Familiar environment-protection skills may effectively prevent environmental accident or disasters, and then decrease political risk, environmental risk and market risk induced by environmental disasters. The available environmental reputations and benefits are valuable

and non-duplicate resources, prominent environmental performance may create larger financial benefits, reduce corporate risk exposure and meet stakeholders' market expectation.

Hypothesis 3. Environmental information disclosure has a U-shaped relationship with corporate risk exposure.

3 Research methodology

Corporate risk exposure refers to the uncertainty of future cash flow, risk exposure is divided into systemic risk and idiosyncratic risk exposure on the basis of investment theory. Based on Fama-French three factors model, idiosyncratic risk exposure is estimated as the equation (1) [31-32].

$$R_{it} = \alpha_0 + \alpha_m R_{mt} + \alpha_{SMB} SMB_{it} + \alpha_{HML} HML_{it} + \varepsilon_{i,t} \quad (1)$$

Where i denotes corporate, R_{mt} refers to the excess returns of stock price, which is estimated based on the difference between the returns of stock price for corporate i and the average returns of industrial stock prices without disclosing environmental information. SMB_{it} refers to the total market value for corporate i , HML_{it} refers to net returns of book-to-market value per share for corporate i , ε_{it} is the residual errors. Based on the above three hypothesis, we propose the two models as follow.

$$SR_{it} = \beta_0 + \beta_1 EID_{it} + \beta_2 EID_{it}^2 + \beta_3 SIZE_{it} + \beta_4 LEV_{it} + \beta_5 ROA_{it} + \beta_6 IR_{it} + \xi_{it} \quad (2)$$

$$IR_{it} = \gamma_0 + \gamma_1 EID_{it} + \gamma_2 EID_{it}^2 + \gamma_3 SIZE_{it} + \gamma_4 LEV_{it} + \gamma_5 ROA_{it} + \gamma_6 SMB_{it} + \zeta_{it} \quad (3)$$

Where IR_{it} is the idiosyncratic risk, EID is environmental information disclosure, $SIZE$ is corporate sizes which denotes the logarithm of total assets book value. LEV is the asset-liability ratios, ROA is the returns of assets, and $SIZE$, LEV , ROA are all controlling variables. $SIZE$ controls the correlation between environmental information disclosure and corporate size, ROA controls the correlation between environmental information disclosure and risk exposure.

4 Data source and environmental information disclosure estimation

4.1 Data samples source

Considering the continuity and comparability of corporate environmental information disclosure, we select the social responsibility reporting and sustainable environment reporting in heavy pollution industries, such as thermal power, steel and nonferrous metal industries from 2008 to 2013, including thermal power industry has 23 corporations, steel industry has 16 corporations, nonferrous metal industry has 19 corporations. We remove the short of annual social responsibility reporting and environmental reporting, and collect 343 social responsibility reports and environmental reports, which are sourced from syntao-sustainability solutions network and CNINFO network. Environmental information disclosure index is scored by 30 environmental information indicators issued by global reporting initiative (GRI) in 2006, and other financial indicators are sourced from CSMAR database and GENIUS finance database.

4.2 Environmental information disclosure estimation

Environmental information disclosure index is estimated by the ratio of actual score sum divided by optimal score sum in 30 environmental information disclosure indicators. It is quantitative estimation on the basis of the difference of 30 environmental information disclosure indicators, concluding 17 core indicators and 13 supplementary indicators. Estimated criteria are as follow: for the core indicators, we estimate the combination of qualitative analysis and quantitative evaluation, detailed information disclosure is given 5 score, however non-detailed information disclosure is given 3 in the combination of qualitative and quantitative evaluation. Only qualitative information evaluation is given 1.5 score, and undisclosed information is given 0 score. For the supplement indicators, detailed information disclosure is given 3 score, non-detailed information disclosure is given 1 score and undisclosed environmental information is given 0 score.

4.3 Statistical analysis of environmental information disclosure

Figure 1 indicates corporate environmental information disclosure in thermal power, steel and nonferrous metal industries. Environmental information disclosure for most of corporate is less than 0.5, while environmental information disclosure for minority corporate is more than 0.5, and the overall score of environmental information disclosure exhibits a lower level. In table 2, the mean of corporate environmental information disclosure are 0.2013, 0.2139, 0.2201, 0.2360, 0.2413 and 0.2506 from 2008 to 2013, corporate environmental performance exhibits an increasing trend. More and more corporate in thermal power, steel and nonferrous metal industries pay much attention to environmental information disclosure, which help stakeholders make scientific investment decisions. The standard deviation of corporate environmental information disclosure are 0.1176, 0.1232, 0.1236, 0.1467, 0.1274 and 0.1577, it shows that different corporate exhibit a greater difference in disclosing environmental information during 2008-2013.

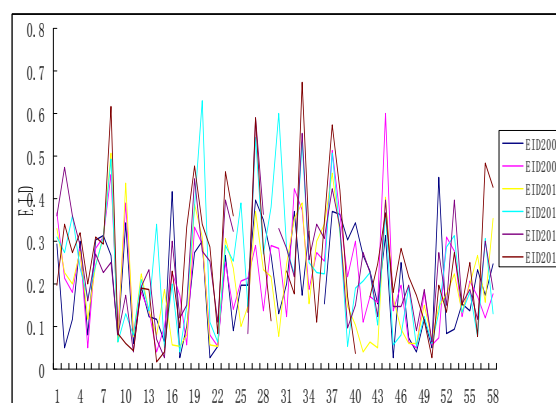


Figure 1. Corporate environmental information disclosure (EID) in thermal power, steel and nonferrous metal industries during 2008-2013.

Table 1. Statistical results of corporate environmental information disclosure

EID	mean	Standard deviation	maximum	minimum
2008	0.2013	0.1176	0.4516	0.0282
2009	0.2139	0.1232	0.6008	0.0403
2010	0.2201	0.1236	0.5081	0.0403
2011	0.2360	0.1467	0.6290	0.0403
2012	0.2413	0.1274	0.5887	0.0282
2013	0.2506	0.1577	0.6734	0.0161

5 Empirical results analysis and discussions

5.1 Empirical results of Fama-French model

Our empirical investigations of Fama-French model are shown in table 2. Total market value, excess returns of stock price, and net returns of book-to-market per share are all exhibit significantly positive correlation with returns of stock price at the significance of 5% level, and their *t*-statistical value are more than 1. From the fixed effects of cross-section data, our results indicate their link exhibits a significantly periodic divergence on returns of stock price during 2008-2013, and returns of stock price have significant market risk, corporate size risk and net returns risk of book-to-market at the confidence level of 5%.

Table 2 Empirical results of Fama-Frenc model

variables	<i>Intercept term</i>	R_{mt}	SMB_{it}	HML_{it}
coefficients	-0.228* (-1.261)	1.085*** (45.40)	0.05** (1.99)	1.55** (2.00)
Fixed effect				
C2008	-0.776	C2011	-0.433	
C2009	1.388	C2012	-0.063	
C2010	-0.008	C2013	-0.117	
R^2	0.955	AIC	0.844	
F-statistical value	898.43			

Note: ** significance of the estimated coefficients at the significance levels of 5%, *** significance of the estimated coefficients at the significance levels of 1%. The numbers in parentheses are *t*-statistical values.

5.2 causality test between EID and risk exposure

Panel data are two mixed dimensions both time series data and cross-section data, which reflect the difference of sectional individuals and time dynamics of individuals. Granger causality test in panel data is more accurate than time series data, increase sample data capacity and improve the freedom of Granger causality test, and then effectively weaken the multi-collinearity effect of explanatory variables and improve the accuracy of model evaluation. Popular unit root methods of panel data are LLC, IPS, FISHER, we propose these methods to unit root test of panel data for environmental information disclosure, returns of stock price, and idiosyncratic risk, and their results are shown in table 3. Environmental information disclosure, returns of stock price, and idiosyncratic risk have no unit root at the significance of 1% level

under the LLC, IPS, FISHER method of panel data, and they are stationary variables.

Table 3. The results of unit root test of environmental information disclosure and risk exposure

variable	EID		EID ²	
	statisti	probabilit	statisti	probabilit
method	c	y	c	y
LLC	-16.10	0.0000	-17.94	0.0000
IPS	-14.64	0.0000	-15.84	0.0000
FISHER	178.46	0.0000	196.79	0.0000
-ADF			8	
FISHER	178.82	0.0000	196.65	0.0000
-PP				
variable	SR		IR	
method	statisti	probabilit	statisti	probabilit
	c	y	c	y
LLC	-13.10	0.0000	-6.62	0.0000
IPS	-11.55	0.0000	-8.07	0.0000
FISHER	136.51	0.0000	102.59	0.0000
-ADF				
FISHER	147.04	0.0000	116.73	0.0000
-PP				

Table 4. The cointegration relationship between EID and risk exposure

EID, SR and IR cointegration			
Test methodology		SR	IR
Pedroni	PC ₁ (ADF)	-7.6038***	-8.0462***
	PC ₂ (ADF)	-7.5632***	-8.5523***
Fisher	0	122.6***	114.7***
	cointegration vector		
	1	97.22***	73.88***
	cointegration vector		
EID ² , SR and IR cointegration			
Test methodology		SR	IR
Pedroni	PC ₁ (ADF)	-9.6707***	-10.0812***
	PC ₂ (ADF)	-9.3505***	-10.0643***
Fisher	0	146.9***	141.0***
	cointegration vector		
	1	107.8***	87.89***
	cointegration vector		

Note: *** significance of the estimated coefficients at the significance levels of 1%.

The co-integration relationship among environmental information disclosure, returns of stock price and idiosyncratic risk are shown in table 4. Environmental information disclosure, returns of stock price and idiosyncratic risk reject the null hypothesis and exhibit a significant co-integration relationship at the confidence level of 1% using Pedroni and Fisher methods, which are significant causal relationship. As a result, environmental information disclosure has a significant impact on stock price risk and idiosyncratic risk exposure, these results significantly support hypothesis 1.

5.3 Empirical results and discussions

Table 5 indicates the results of multiple linear regression of the effect of environmental information disclosure on stock price risk exposure and control variables. Here stock price risk exposure is defined by the returns of stock price on the basis of change rate of stock price. The related coefficient between EID and stock price risk is -1.1535, and *t*-statistical value is more than 1, which indicates that environmental information disclosure has a significantly negative impact on stock price risk at the confidence level of 5%. However the related coefficient between EID^2 and stock price risk is 1.6792, and *t*-statistical value is greater than 1, which suggests that EID^2 has a significantly positive effect on stock price risk at the significance level of 5%. The related coefficient between idiosyncratic risk and stock price risk is 2.1223, which shows that corporate idiosyncratic risk has a significantly positive effect on stock price risk. From the fixed effect of panel data, the effect of EID on stock price risk exposure indicates a significantly periodic difference from 2008 to 2013. on the beginning of corporate environment-protection strategy, a large number of environmental protection activities and stringent environmental regulation lead to an increase of corporate operation cost, immature environmental management skills and experiences enhance environmental management inputs, such as assets depreciation costs and capital financing costs due to purchasing environmental protection equipments, residents' health compensation costs, lawsuit costs and ecological restoration costs induced by environmental disasters etc. unfavorable environmental regulation increase corporate financial burdens and reduce market expectation of corporate future earning, and then more environmental information disclosure increase stock price risk exposure. With the continuous

implementation of environmental protection strategy, corporate improve environmental protection skills and experiences, continuous inputs and mature skills in environmental protection promote corporate production process and the efficiency of energy-saving and emission reduction, and then create greater environmental benefits and reduce stock price risk exposure. Firstly, excellent environmental performance indicates that corporate seek to communicate their efforts, achievements with stakeholders in implement environmental responsibility and practices, improve their social image and reputation, enhance consumers' market confidence and then reduce stock price risk exposure. Secondly, prominent environmental performance implies that corporate may decrease the serious consequences of environmental accidents and stock price risk exposure induced by environmental disasters. Thirdly, more environmental information disclosure encourage stakeholders join in corporate environment-protection strategy, enhance stakeholders' market confidence and expectation, and then improve stock price risk exposure. Our empirical results show that environmental information disclosure has a significant U-shaped relationship with stock price risk exposure, these results support hypothesis 3.

Table 5. Empirical results of the effect of environmental information disclosure on stock price risk disclosure.

<i>variables</i>	<i>Intercept term</i>	<i>EID</i>	<i>EID²</i>	<i>IR</i>
coefficients	0.9403** (2.2513)	- 1.154** (-2.01)	1.6792** (1.7317)	2.122*** (3.0359)
variables	SIZE	LEV	ROA	
coefficients	- 0.0362** (-1.961)	-0.0019 (-0.03)	0.8657*** (2.4527)	
	Fixed effects			
C2008	-0.6838	C2011	-0.2903	
C2009	1.1505	C2012	0.0865	
C2010	-0.1613	C2013	-0.1200	
R ²	0.711	F-	73.35	
		statistic value		
AIC	1.052			

Note:** significance of the estimated coefficients at the significance levels of 5%, *** significance of the estimated coefficients at the significance levels of 1%. The numbers in parentheses are *t*-statistical value.

Table 6. Empirical results of the effect of environmental information disclosure on corporate idiosyncratic risk disclosure.

<i>variables</i>	<i>Intercept term</i>	<i>EID</i>	<i>EID²</i>	<i>SIZE</i>
coefficients	0.0019*	-0.091*	0.117*	-
ts	(1.049)	(-2.06)	(1.559)	0.007*** (-4.03)
variables	LEV	ROA	SMB	
coefficients	0.0026	-0.005	0.0089*	
ts	(0.4508)	(-0.16)	** (3.983)	
Fixed effects				
C2008	-0.0222	C2011	-0.0201	
C2009	0.0327	C2012	-0.0181	
C2010	0.0404	C2013	-0.0152	
R ²	0.5037	F-	30.27	
		statisti		
		c value		
AIC	-4.072			

Note: * significance of the estimated coefficients at the significance level of 10%, ** significance of the estimated coefficients at the significance levels of 5%, *** significance of the estimated coefficients at the significance levels of 1%. The numbers in parentheses are t-statistical value.

Table 6 indicates the empirical results of the effect of environmental information disclosure on corporate idiosyncratic risk exposure. EID has a significantly negative impact on corporate idiosyncratic risk exposure at the confidence level of 10%, however *EID²* has a significantly positive effect on corporate idiosyncratic risk exposure at the significance level of 10%, these results exhibit that EID has a significant U-shaped relationship with corporate idiosyncratic risk exposure at the significance level of 10%. From the empirical results of fixed effect, environmental information disclosure has a significantly periodic difference with corporate idiosyncratic risk during 2008-2013. those empirical results support hypothesis 1 and 3. Environmental information disclosure is an important factor driving the changes of corporate stock price. In the information asymmetric stock market, environmental information implies complexity and asymmetry, corporate stock price cannot reflect all market information. When corporate disclose more environmental information, market investors gain consistent consensus for environmental information, adjust the market expectation of stock price, and then corporate stock price will make market adjustment. When corporate disclose more environmental information, market investors are anxious that a good many environmental protection inputs increase corporate financial burdens and idiosyncratic risk exposure. Continuous environmental information disclosure

may improve corporate social image and reputation, market investors strengthen market confidence of corporate future profitability and market expectation of stock price, and then reduce corporate idiosyncratic risk exposure. Outstanding environmental information disclosure promote market investors market expectation of future operation prospects, attract investors buy corporate stock as current market price, and then further affect the price and volume of corporate stock. In brief, when corporate disclose more environmental information, market invest worry a large number environment-protection inputs about increasing corporate financial burdens and idiosyncratic risk exposure, accordingly environmental information disclosure has a significantly negative impact on corporate idiosyncratic risk exposure. Continuous environmental information disclosure deliver favorable market signals, adjust investors' market expectation, corporate stock price will make the appropriate adjustment, thereby environmental information disclosure has a significant U-shaped relationship with corporate idiosyncratic risk exposure.

6 Conclusions and policy implications

We investigate the effect of environmental information disclosure on stock price risk and idiosyncratic risk exposure using panel data in thermal power, steel and nonferrous metal industries. The statistical results show that corporate environmental information disclosure exhibits an obviously increasing trend during 2008-2013, and different corporate have greater periodic divergence in environmental information disclosure. Our empirical results suggest that excess market returns of stock price, corporate size and net returns of book-to-market value per share exhibit a significant impact on returns of stock price at the significance level of 5% using Fama-French three factor model. We verify that environmental information disclosure, stock price risk and corporate idiosyncratic risk exposure are stationary variables using LLC, IPS and FISHER methods. Using Pedrini and Fisher co-integration test, we investigate that corporate environmental information disclosure has a significant causality relationship with stock price risk and corporate idiosyncratic risk exposure, these results support hypothesis 1.

On the beginning of corporate environmental protection strategy, a good many environmental protection activities and stringent environmental regulation cause greater political costs, immature environmental management skills increase environment-protection inputs and environment-related costs, environmental disasters promote corporate financial burdens and reduce stakeholders market expectation of future earnings, and then more environmental information disclosure increases stock price risk exposure. Our empirical results exhibit that environmental information disclosure has a significantly negative impact on stock price risk exposure at the significance level of 5%, and these results support hypothesis 2. With sustainable improvement of environmental protection strategy, continuous inputs and mature skills in environmental protection activities may improve corporate production process and energy-saving efficiency, and then create greater environmental benefits and reduce stock price risk exposure. Our empirical results indicate that environmental information disclosure has a significant U-shaped relationship with stock price risk exposure at the significance level of 5%. Outstanding environmental information disclosure deliver favorable market signals, improve corporate social image and reputation, strengthen investors' market expectation, corporate stock price can reflect market information. As a result, our results suggest that excellent environmental information disclosure has a significant U-shaped relationship with corporate idiosyncratic risk exposure at the confidence level of 10%. Those results support hypothesis 3.

We propose policy implication as follows. Firstly, corporate should carry out the whole environmental quality management system, and highlight strategic environmental responsibility, increase environmental protection inputs and disclose more environmental investment expenditure, make a scientific environment-protection strategy, corporate managers believe sustainable environmental management practices may improve corporate financial performance and reduce stock price risk

exposure in the long term. Managers should seek the best balance among environmental performance, financial performance and risk exposure. Secondly, government should formulate effective environmental regulation policy, encourage corporate to focus on environmental responsibility, strengthen the effect of environmental performance on risk exposure, guide appropriate market reactions induced by environmental accidents. Thirdly, environmental regulators should establish the transparency and openness of environmental information disclosure, strengthen public supervision and social-political pressure in environmental management activities. Fourthly, environmental regulators should strengthen law enforcement and punishment, promote capital market efficiency, and voting their foot of market investors increase market punishment due to corporate environmental violations, and then protect stakeholders' interests.

Acknowledgements

The authors are grateful for research support from Research Planning Foundation on Humanities and Social Sciences of Ministry of Education (14YJC790007; 14YJC790167); Philosophy, Society and Science Planning of Zhejiang province (15NDJC123YB); the Collaborative Innovation Center of Local Finance, Zhejiang University of Finance & Economics.

References:

- [1] Russo, M.V., Fouts, P.A. A resource-based perspective on corporate environmental performance and profitability. *Academy of Management Journal*, Vol.40, No.3, 1997, pp. 534–559.
- [2] Dowell, G., Hart, S., Yeung, B. Do corporate global environmental standards create or destroy market value. *Management Science*, Vol.46, No.8, 2000, pp.1059–1074.
- [3] Earhart, D., Lizal, L. Effects of ownership and financial performance on corporate environmental performance. *Journal of Comparative Economics*, Vol.34, 2006, pp.111-129.
- [4] Clarkson, P. M., Overell, M B., Chepple, L.

Environmental reporting and its relation to corporate environmental performance. *Journal of Accounting, Finance and Business Studies*, Vol.47, No.1, 2011, pp.27-60.

[5] Zeng, S. X., X, X. D., Dong, Z. Y. et al. Towards corporate environmental information disclosure: an empirical study in China. *Journal of Cleaner Production*, Vol.18, 2010, pp.1142-1148.

[6] Zeng, S. X., Xu, X. D., Yiu, H. T, et al. Factors that drive Chinese listed companies in voluntary disclosure of environmental information [J]. *Journal of Business Ethics*, Vol.109, No.3, 2012, pp.309-321.

[7] Orlitzky, M., Schmidt, F.L., Rynes, S.L. Corporate social and financial performance: a meta-analysis. *Organization Studies*, Vol.24, No.3, 2003, pp.403-441.

[8] Salama, A. A note on the impact of environmental performance on financial performance. *Structural Change and Economic Dynamics*, Vol.16, 2005, pp.413-421.

[9] Nakao, Y., Amano, A., Matsumura, K., et al. Relationship between environmental performance and financial performance: an empirical analysis of Japanese corporations. *Business Strategy and the Environment*, Vol.16, No.2, 2007, pp.106-118.

[10] Lucas, M. T., Wilson, M. A. Tracking the relationship between environmental management and financial performance in the service industry. *Service Business*, Vol.2, 2008, pp.203-218.

[11] Monevan, J. M., Ortas, E. Corporate environmental and financial performance: a multivariate approach. *Industrial Management & Data Systems*, Vol.110, No.2, 2010, pp.193-210.

[12] Thoumy, M., Vachon, S. Environmental projects and financial performance: Exploring the impact of project characteristics. *International Journal of Production Economics*, Vol.140, 2012, pp. 28-34.

[13] Konar, S., Cohen, M. A. Does the market value environmental performance?. *The Review of Economics and Statistics*, Vol.83, No.2, 2001, pp.281-289.

[14] Iwata, H., Okada, K. How does environmental performance affect financial performance? evidence from Japanese manufacturing firms. *Ecological Economics*, Vol.70, 2011, pp.1691-1700.

[15] Filbeck, G, Gorman R F. The relationship between environmental and financial performance of public utilities. *Environment and Resource Economics*, Vol. 29, 2004, pp.137-157.

[16] Sueyoshi, T., Goto, M. Can environmental investment and expenditure enhance financial

performance of US electric utility firms under the clean air act amendment of 1990?. *Energy Policy*, Vol.37, 2009, pp.4819-4826.

[17] Jacobs, B. W, Singhal, V. R, Subramanian, R. An empirical investigation of environmental performance and the market value of the firm. *Journal of Operations Management*, Vol.28, 2010, pp.430-441.

[18] Lioui, A., Sharma, Z.. Environmental corporate social responsibility and financial performance: disentangling direct and indirect effects. *Ecological Economics*, Vol.78, 2012, pp.100-111.

[19] Desgagne, B. S., Gozlan, E. A theory of environmental risk disclosure. *Journal of Environmental Economics and Management*, Vol.45, No.2, 2003, pp. 377-393.

[20] Simon, T. Just who is at risk? the ethics of environmental regulation. *Human and Experimental Toxicology*, Vol.30, No.8, 2010, pp. 795-819.

[21] Campbell, D., Slack, R. Environmental disclosure and environmental risk: Sceptical attitudes of UK sell-side bank analysts. *The British Accounting Review*, Vol.43, No.2, 2011, pp.54-64.

[22] Vasi, I. B., King, B. G. Social movements, risk perceptions, and economic outcomes: the effect of primary and secondary stakeholder activism on firms' perceived environmental risk and financial performance. *American Sociological Review*, Vol.77, No.4, 2012, pp.573-596.

[23] Dobler, M., Lajili, K., Zéghal, D. Environmental performance, environmental risk and risk management. *Business Strategy and the Environment*, Vol.23, 2014, pp.1-17.

[24] Chang, K. The effects of ownership and capital structure on environmental information disclosure: empirical evidence from Chinese listed electric firms. *WSEAS Transaction on System*, Vol.12, No.12, 2013, pp.637-649.

[25] Chang, K., Zhang, L. The effects of corporate ownership structure on environmental information disclosure—empirical evidence from unbalanced panel data in heavy-pollution industries in China. *WSEAS Transaction on System and Control*, Vol.10, 2015, pp.405-414.

[26] Chang, K. The Environmental Kuznets Curve effects of energy intensity and emission intensity on optimizing Chinese emission-reduction under the constraint of energy-saving policy. *WSEAS Transaction on System*, Vol.13, No.1, 2014, pp.390-391.

[27] Neri, F. Quantitative estimation of market sentiment: A discussion of two alternatives. *WSEAS Transaction on System*, Vol.11, No.12, 2012, pp.691-702.

[28] Neri, F. Open research issues on computational techniques for financial applications. *WSEAS Transaction on System*, Vo.13, 2014, pp.403-412.

[29] Neri, F. Open research issues on advanced control methods: Theory and application. *WSEAS Transaction on System*, Vo.13, 2014, pp.272-273.

[30] Sun, W., Cui, K.. Linking corporate social responsibility to firm default risk. *European Management Journal*, Vol.32,No.2, 2014,pp. 275–287.

[31] Fama E., French, K. Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, Vol.33, 1993, pp.3–53.

[32] Fama, E., French, K. Multifactor explanations of asset-pricing anomalies. *Journal of Finance*, Vol. 51, 1996, 55–84.