The Impacts of Environmental Policies on the Stock Prices of Energy Companies in China

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Abstract

This paper investigates the impact of environmental policies on the stock price of China's listed energy companies. We employ the event study methodology and the EGARCH model to examine the abnormal returns of listed energy companies under environmental regulation between 2007 and 2015 in China. We divide environmental policies into three categories: market based regulation (MBR), command and control regulation (CCR, including legislative control and administrative control), and environmental information disclosure (EID). We conclude that generally, environmental regulations had a significant and negative impact on stock price of listed energy companies in short time. However, the impact of EID is positive; and the impact of MBR is statistically insignificant. Meanwhile, the impact of environmental regulation on the stock price of China's listed energy companies is different in different sectors and regions. The impact in electricity and coal industries is statistically negative, but the impact in oil & gas industry is statistically insignificant; the impact in eastern and middle regions is statistically negative, but in western regions it is statistically insignificant. Moreover, for different companies with different percentages of nationalization and scales, the impact is also different. Higher percentages of nationalization, lower negative impact is. An interesting finding is that the companies with middle-scale are affected negatively most. Finally, a surprising finding is the negative impact of environmental policies is relatively high for the listed energy companies with more environmental information disclosure. We provide explanations of these results and yield policy implications.

Keyword: Environmental regulation; Energy companies; Stock price; China; Event study

1. Introduction

Various strategies have been employed in China to fight against the increasing burdens of environmental pollution and carbon emission. Among them, government regulations have been counted as an important and effective category, especially those targeting on corporate behaviors, since industrial

corporations represent the largest emitter of carbon and pollution in China. It is generally believed that environmental regulations could exert fundamental influence over a corporate, because they may not only alter the corporate's inner organization for better environmental management, but also influence outside investors' perception of the corporate's value, as well as their products in the markets.

While these regulations are generally believed beneficial to the environment, it's quite controversial to conclude their impacts' on corporate values. On one extreme, environmental regulations are assumed as a burden imposed by a government that compromises a corporate productivity and consequently its competitiveness (Palmer et al., 1995). This view relies on conventional economic logic that companies have already optimized their use and allocation of all kinds of resources and any intervention means deviation from such optimal equilibrium. Specifically, environmental regulations usually require companies to engage in nonprofit activities, such as waste disposal, carbon mitigation, or environmental audits (Gray and Shadbegian, 1995; Haveman and Christiansen, 1981). In case of noncompliance, companies may also have to pay environmental fines or be involved in environmental lawsuits (Stewart, 1993; Gray and Shadbegian, 1995; Haveman and Christiansen, 1981). Spending on those nonproductive activities may crowd out a company's potential investment in production expansion or technological innovation (jaffe and Palmer, 1997; Thomas, 2009).

On the other extreme, behavioral modifications adopted under the guidance of environmental regulations represent unique opportunities for improving a company's financial performance. First, as a regulated company takes on environmental-friendly practices, it may be exposed to unique opportunities to increase revenues. For example, it is usually easier for reputational green enterprises to get connected with green consumers and become popular in the green markets (Huang and Kung 2010; Jose and Lee 2007). Moreover, the green technologies and innovations developed with the pressure of environmental regulations can be attractive for other peer enterprises and create a business opportunity for those inventors. The positive link between green practice and profit performance has been studied in a variety of empirical studies (Lopez-Gamero et al., 2010; Song and Wang, 2011, Zhao et al. 2015). Second, as the famous "Porter Hypothesis" suggests, "Pollution is a manifestation of economic waste and involves unnecessary or incomplete utilization of resources" (Porter & van der Linde, 1995, p. 99). Thus, reducing pollution can be coincided with reduction in the costs of raw materials, energy, and services. Under the pressure of environmental regulations, companies may adopt some profit-increasing innovations that they should adopt but not because of improper market power, contractual incompleteness, asymmetric information within companies, and restriction of knowledge spill-overs. In additional to operational costs, green companies can also save their financing costs, as socially responsible financial institutes have developed an increasingly number of green mutual funds or green credit programs that charge lower interests on loans to green enterprises (Motoko and Yang, 2010; Liu et al, 2007). Finally, environmentally regulated companies may shield themselves from certain market risks, that also makes them better investment targets in the financial markets. They are less likely to be involved in conflicts with local communities, environmental disputes with government agencies, or negative news coverage by public media (Gemmell and Scott, 2013; Ted, 2011; Gouldson et al. 2009).

Such risk consideration especially concerns multinational corporations that face constantly changing environmental standards in quite diversified business environments. It is a common pattern that environmental standards are raised with increases in per capita income, and more strictly regulated enterprises may be more readily adapt to the challenges caused by rising environmental standards compared to those defaulting to currently lower local standards (Porter, 1990).

As investors recognize the potential influence of environmental regulations on a company's profits, costs, and risks, they would adjust their valuation of the company with the announcement of new regulations. Such strategic re-valuation among investors generally exists in a market, and its consequences will be finally reflected in the changes of stock prices. Thus, there are some studies investigating the relationship between environmental regulation and stock price (Ramiah et al. 2013; Yamaguchi, 2008; Xu et al. 2012; Amato and Amato, 2012; Lorraine et al. 2004; Kong et al. 2014). In these studies, environmental regulation can be categorized into two groups. One is the general environmental regulation instruments, such as "the Kyoto Protocol on climate change comes into force", "government's Carbon Pollution Reduction Scheme", etc. Using an event study methodology, Ramiah et al. (2013) found that the carbon pollution reduction scheme (CPRS) announcement in Australia had a negative impact on the stock, for example, Australian submitting its target range to the Copenhagen Accord made a cumulative abnormal return of -31% occur in the alternative energy sector. Thomas (2001) also found that environmental regulation had a negative impact on stock price. While, contrary to the above two results, Kong et al. (2014) found that the carbon emission rights trading scheme (CERTS) in China increased the market values of firms in the environment industry.

The other kind of environmental regulation that has been studied in this field is the information disclosure of environmental performance (or environmental violation events). Yamaguchi (2008) stated that the information disclosure of environmental performance have different effect on the stock price of firms with different levels of environmental management ranking. It is found that market reaction to corporate environmental performance has a positive effect for the higher frequency of ranking and a negative effect for the lower frequency of ranking. In this study, we do not explore the impact of environmental regulation on the stock price of China's listed energy companies. Similar with this result, Amato and Amato (2012) examined the impact of Newsweek's "The Greenest Big Companies in America" on stock values for large companies in the U.S. They concluded that a positive impact on stock values from favorable environmental recognition but no effect for low ranked firms. Xu et al. (2012) investigated the stock market's reaction to information disclosure of environmental violation events in China. They argued that the negative environmental events of Chinese listed companies currently have weak impact on the stock market than other countries. Lorraine, et al. (2004) analyzed the impact of environmental performance publicity (either good or bad) on stock price. They found that the bad news, such as the details on fines has a significant impact on share price.

Our contributions to the current literature are: first, we divide further general environmental regulation into two types: command and control regulation (CCR), market based regulation (MBR), and analyzed the various impact of three types of environmental regulation on the stock price of China's energy listed

companies: CCR, MBR and environmental information disclosure. Second, we explore the different impact of environmental regulation on the stock price by distinguishing various regions, energies, scales. Third, we investigate the role of ownership in the relations between environmental regulation and the stock price.

The remainder of the paper is organized as follows. Section 2 is the description of environmental regulation. Section 3 provides the research hypothesis. Section 4 is methodology and data collection. Section 5 presents empirical results and discussions. Section 6 concludes and provides some policy implications.

2 Description of environmental regulation

Environmental resources were once considered as public goods and free to use. But since the society moved into the industrialized one with the economic and population growth, environmental resources started to show scarcity. The traditional industrial development model often means a huge resource consumption and waste at the expense of serious damage to the environment to promote economic development. This mode has been proved unable to sustain human to harmoniously co-develop with the nature. Facing with increasingly severe environmental problems, environmental regulation becomes an inevitable choice.

Regulation is the general term of government intervention in the market. Reducing the efficiency losses of market failure as well as readjusting and reallocating the internal social welfare to improve the overall welfare are the basis of government regulation. Specifically, government regulation refers to the restrictions on the economic activities of the economic entity, in order to realize the certain purpose of the government. And by the virtue of its legal rights, a government imposes the restrictions in the means of legislation, setting license, supervision and inspection, administrative punishment and administrative rulings etc. The purpose of the restrictions is to establish the rules for the market operation and corporate behavior in order to compensate for market failure, and to ensure the orderly operation of the micro economic and to maximize social welfare.

The earliest environmental regulation can be traced back to the year of 1273, when London passed a decision of controlling smoke dust. And in the early of nineteen century, the United Kingdom established the Conference Committee of studying smoke dust. However, the environmental issue had been troubling the United Kingdom for long time, and the fatal London Fog happened in 1952 led to the promulgation of the *Clean Act Law* in 1956. Around the same time (in 1955), the *Air Pollution Control Law* was issued in the United States; and in 1963, the *Clean Act Law* of the U.S. was promulgated. Moreover, to strengthen environmental regulations, the Environmental Protection Agency (EPA) was established in 1970 in the U.S. The mission of the agency is to protect and enhance the environment to the fullest extent possible under laws enacted by Congress (Atkinson, 1980). These environmental regulations encouraged companies to make external environmental costs internalized, and thus promote environmental improvement in these countries (Kolstad, 2000).

In 1978, China began an economic system reform and since then its economy has entered into a rapid development track. However, such a high rate of economic growth is accompanied with large amount of energy consumption dominated by dirty burning coal, and accordingly produced serious environmental pollution. China's government early realized the importance of environmental protection. And just at the time of China's economic system reform launching, the government promulgated the "Environmental Protection Law (Trial)" in 1979. With the aggravation of poor air quality and environmental degradation, China's government is more aware that environmental protection is a cornerstone of its commitment to more balanced economic growth (Mishra and Smyth, 2011). "As part of the Chinese Government's commitment to more balanced growth, under the Hu-Wen administration, the State Environmental Protection Authority (SEPA) of China has been elevated to full ministerial status. This has empowered SEPA to push for more stringent implementation and monitoring of environmental regulations." (Mishra and Smyth, 2011, P1077) In order to improve the effectiveness of environmental regulation, China's government gradually establishes an integrated policy system including command-and-control instruments, market incentives based instruments, and information disclosure regulations, which are combines by public participation. (Yang, 2009).

Table 1 shows the environmental regulation documents issued from 2007 to 2015 in China. We selected 14 significant environmental policies, and 5 of them were passed by the National People's Congress or the Congress Standing Committee. These 5 documents promulgation should undergo a series of processes, such as the first deliberation, the second deliberation. These processes are included in our analysis. Hence, altogether there are 20 "policies" in our study (Table 1). These regulations are divided into three kinds of categories: (1) command and control based regulation (CCR). It is further divided into two types: legal based policy and administrative based policy. Table 1 indicates that command and control based environmental regulations still occupies a leading position in China. (2) Market based regulation (MBR). Different from CCR, MBR is more likely to raise intrinsic motivation for companies to follow environmentally friendly development strategy. Traditionally, MBR includes tradable permits, pollution charges, and refund systems (Walley and Whitehead, 1994). In this study, "Long-term development plan for renewable energy" (Plan) issued in Aug. 2007 is categorized into MBR, this is because it is mentioned in this Plan that the incentive policies of promoting renewable energy include favorable fixed feed-in tariff (FIT), investment subsidies, and tax preference, etc. Moreover, it is emphasized in this Plan that the principles of promoting renewable energy are: "renewable energy technologies are motivated to be adopt for resolving energy shortage and without access to electricity issue in rural areas based on economic incentive policies", "market based institution for promoting renewable energy should be set up, and market based instruments should be used to encourage investment in renewable energy". (3) Environmental information disclosure (EID). It requires companies to regularly or irregularly disclose environmental information, such as the bulletin of pollution incidents, the national or regional environmental report as well as possible effects of contamination on human health; Or it requires to establish environmental labelling and/or environmental signal system or

environmental quality standards, such as the ISO 14000 environmental management certification system; It also refers as companies make voluntarily disclose environmental management information.

Table 1 China's major environmental regulations from 2007 to 2015

NO.	Issue Time	Issue Department	Environmental Policy	Policy Type
1	June.07.2007	NDRC	Long-term development plan for renewable energy	MBR
2	Aug.27.2007	NPC	Circular Economy Promotion Law (First deliberation)	Legislative
3	Nov.17.2007	State council	Energy conservation and emissions reduction statistical monitoring and assessment of implementation plan	Administrative
4	Jan.15.2008	NDRC	Pollution prevention of acid rain and carbon dioxide in the 11th five-year plan	Administrative
5	May 14. 2008	SSE	Guidance of environmental information disclosure in listed companies	EID
6	June 25.2008	NPC	Circular Economy Promotion Law (Second deliberation)	Legislative
7	Aug.29.2008	NPC	Circular Economy Promotion Law (promulgation)	Legislative
8	Aug. 10.2009	NPC	Resolution on tackling climate change (draft)	Legislative
9	Aug.27.2009	NPC	Resolution on tackling climate change (final)	Legislative
10	Jan.19.2010	MEP	Publish environmental administrative penalties	Administrative
11	May.4.2010	State council	Notification of "Further intensify efforts to ensure the realization of the emission reduction targets in the eleventh five-year plan"	Administrative
12	Aug.29.2011	MEP	Main pollutants emission in China, 2011	EID
13	Oct.24.2011		Clean Production Promotion Law (draft discussion)	
14	Jan. 13. 2012	NDRC	Seven experimental carbon exchanges will be established in China	MBR
15	Feb.29.2012	NPC	Clean Production Promotion Law (promulgation)	Legislative
16	Sep.10.2013	State council	Air Pollution Control Action Plan	Administrative
17	April.24.2014	NPC	Environmental Protection Law (revised)	Legislative
18	Dec.22.2014	NPC	Air Pollution Prevention and Control Law (First deliberation)	Legislative
29	June 30.2015	NPC	Air Pollution Prevention and Control Law (Second deliberation)	Legislative
20	Aug.29.2015	NPC	Air Pollution Prevention and Control Law (promulgation)	Legislative

Note: NDRC: National Development and Reform Commission ; SSE : Shanghai Stock Exchange

NPC : National People's Congress ; MEP : Ministry of Environmental Protectio

3 Research hypothesis

As our previous discussion, some studies argued that environmental regulation affect negatively stock price (Ramiah et al. 2013; Thomas, 2001), while a few studies stated that positive correlation exists between environmental regulation and stock price (Kong et al. 2014). From a short run perspective, environmental regulation generally increase companies' compliance cost and thus has a negative impact on companies' performance (Walley and Whitehead, 1994; Jaffe and Palmer, 1997; Smith, 1992; Beckerman, 1992). The compliance cost mainly includes two types of costs: one is internal cost, including expenditure on environmental protection equipment, investment in environmental technology research and development, environmental management costs and fines, opportunity costs as well. Besides, the government costs of formulation, implementation and supervision of environmental regulations which constitute the external cost of the corporate environmental regulation will ultimately be borne by the enterprises.

However, the famous "Porter Hypothesis" pointed out there is a win-win situation between company performance and environmental regulation since environmental regulation could promote technological innovation and accordingly improve company efficiency (Porter and Linde, 1995), and this Hypothesis has been supported by some studies (Lopez-Gamero et al., 2010; Song and Wang, 2011; Zhao et al. 2015). The above two conflict opinions would be compatible if "time" is considered. From a short run, there is no doubt that environmental regulation will increase compliance cost and thus detriment companies' profit; while from a long run period, environmental regulation can encourage companies to make technological innovation and favour performance improvement. In this study, we concern the impact of environmental regulation on the stock price of energy companies from a short run perspective. Furthermore, Ramiah (2013) found that when the Australian government announced the carbon emission reduction plan, the accumulated abnormal stock earnings of the listed companies in oil and power industry declined. It was believed that the carbon emission reduction would increase the costs of the companies and go against the profits of the two industries. Based on that, here comes up with the first hypothesis 1.

H1: Environmental regulation has a negative impact on stock price of listed energy companies in short term.

The above analysis shows that environmental regulation as a whole has a negative impact on stock price of listed energy companies in short term, however, for different types of environmental regulation, the impact will be different. Lopez-Gamero et al. (2010) argued that MBR has positive effects on company's competitiveness, while AER has no such effect. Downing and White (1986), Milliman and Prince (1989) also pointed out that MBR provide the highest company incentives to promote technological change, while direct controls (CCR) usually provide the lowest relative company incentives to promote technological change. However, these studies focus on a long period analysis. In short time, the impact of MBR and CCR on companies' performance would be different.

From a short run, CCR represented by administrative control and legislative control, has higher level of mandatary, it is signified by "must obedience"; while MBR emphasizes the self-regulation, it has more

flexibility in companies behavior choice comparing with CCR. Similar with MBR, IDR relies more on the initiative of companies themselves and their will to improve the environment. Hence, the compliance costs of MBR and IDR are lower than CCR, and we arrive at the second hypothesis.

H2: The negative effect of MBR and IDR on listed energy companies is less than that of CCR in short time.

China's energy industries mainly include electric power industry, coal industry and oil & gas industry. Comparing with oil & gas industry, electricity and coal industries are facing a greater challenge to control emission. China's electric power industry is now still dominated by coal fired power plants, and more than 70% of power generation is from coal burning. According to the data of *Annual Statistic Report on Environment in China (2015)*, the nitrogen oxides and sulfur dioxides emission in China's electric power industry accounted for 56% and 39% respectively of the total industrial sectors in 2014. Meanwhile, according to the data of IEA, the carbon dioxides emission in China's electric power industry accounted for 50% of the total industrial sectors in 2014. Meanwhile, coal mining is also a high energy and pollutant intensive industry (Yan and Zhao, 2016). Hence, we get the third hypothesis.

H3: Environmental regulation has greater negative effects on the stock price of electricity and coal companies than oil and gas companies.

As our previous discussion, IDR has become a significant instrument used by policy makers (Evans et al. 2009; Criado-Jimenez et al. 2008). According to China's IDR, two types of companies are mandated to disclosure environmental information: one is the companies that discharge pollutants above the levels specified by governments; the other is the companies that fall into one of the thirteen selected industrial sectors applying for public listing or refinancing in the stock market (Zeng et al. 2012). Meanwhile, China's government encourages companies to release their environmental information on a voluntary basis. We wonder in the context of environmental regulation, whether the difference in information disclosure degree of pollutant discharge affects the stock price of energy listed companies.

In theory, environmental resources are public resources belong to the whole society. Companies should bear the social responsibilities for the usage, maintenance and management of environment and disclose environmental information to the public, to inform the government and the public of the environmental resource situation. Those companies with more social responsibilities have higher activity to disclose environmental information, and these companies have higher willingness to control their pollutant discharge. Hence, environmental regulation would have less negative impact on these companies' stock price. Plumlee (2009), Lu (2014) found that EID has positive relations with stock price of the listed companies being sensitive to environment, while information disclosure has negative relations with stock price of the listed companies being insensitive to environment. Wang and Choi (2010) concluded that higher level of information disclosure of social reports can obtain a beneficial stock price. Li et al. (2015) stated that carbon information disclosure have significant positive influence on enterprise value creation. Hence, we come to the fourth hypothesis.

H4: Environmental regulations have weaker negative influence on the stock price of listed energy companies that have higher EID level.

Another issue we are interested in is that whether the ownership structure affects the relations between environmental regulation and companies' stock price. Most of China's energy companies are owned by state. State-owned enterprises (SOEs) tend to attract more public attention, and they have higher ability to obtain financial support; Meanwhile, it is more important for the leaders of SOEs to obey government's order than obtaining profit. Hence, SOEs or the companies with higher proportion of state shares have more willingness to obey environmental regulation and have higher ability to bear the increase of compliance cost than private companies or the companies with lower proportion of state shares. According to this, we put forward the fifth hypothesis.

H5: The higher proportion of state share owned by energy companies, the less negative effects of environmental regulation on the stock price of listed energy companies occur.

Meanwhile, we are also interested in whether there are differences in the impacts of environmental regulation on the stock price of listed energy companies across various regions in China. China is vast in territory, and there are significant differences in natural resources, environmental cognition and industrialization level across various regions. In eastern and middle regions, economic development and people's living standards are better than the western regions, so public awareness of environmental protection in China's eastern and middle regions is stronger than western areas. Lee (1971) also pointed out that the people who are in a region with higher level of economic development pay more attention to environmental protection than those who are in a poor region. From this perspective, the negative impact of environmental regulation on companies in eastern and middle areas would be bigger than that in western regions.

Moreover, Zhu (2014) argued that industry was a major source of environmental pollution, and under the condition of shortage of environmental protection funds, a higher industrialization will reduce the efficiency of capital, and consequently influence the operation and development of a company. Since the industrialization in both China's eastern and central areas is higher than that of western areas, we propose the sixth hypothesis.

H6: Environmental regulation has a greater negative effect on the stock price of listed energy companies in eastern and middle regions than that in western regions in China.

Finally, the scale of a company has significant impacts on the relationship between environmental regulation and stock price. From the perspective of organizational capacity, enterprises in different scales have different adaptability to the same environmental policy. Large companies have comparative advantages of financial, human and technical resources which make these companies have more abilities to adapt environmental regulations. Moreover, from the perspective of society, Cowen (1987) argued that larger companies generally get more attentions from the public since they have higher social popularity, and accordingly, they are facing a greater pressure of social environment, institute, and norms than smaller companies. Hence, large companies have been paying more attention on emission control than others, which determines they have limited affection under a new environmental regulation. On the other hand, small-scale

companies have more flexibility to deal with emission control; meanwhile they are not the key objectives of monitoring. Thus, small-scale companies would be facing less pressure of environmental regulation than middle-scale companies. Therefore, we argue that middle-scale companies have the biggest negative impact about the stock price under an environmental regulation comparing with small and large-scale companies. Then, the seventh hypothesis is put forward.

H7: The negative impact of environmental regulation on the stock price of small-scale and large-scale listed energy companies is weaker than that of middle-scale companies.

4 Research methodology and data collection

The event study method is used for analyzing the impact of environmental regulation on listed energy companies. The basic idea of event study it is to evaluate the change of accumulated abnormal returns before and after an event to judge the event impact. By using the Event Study, the first step is to identify an analysis window. Since it is assumed that within an analysis window, no other events happen except the studying event; or even some other events happened, these events could not affect stock price, the analysis window is usually within one month or only around 5 days. In this study, followed by Demirer and Kutan (2010), we set the window period as 20 days.

The second step is to calculate normal return (expected return) of companies, and abnormal return. These abnormal returns are assumed to reflect the stock market's reaction to the arrival of new information. The approach of calculating normal return is based on estimating a market model, which is as follows:

$$R_{\mathrm{i,t}} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t},\ \varepsilon_{i,t} = \sqrt{h_{i,t}} \cdot u_{i,t} \quad (1)$$

Where $R_{\mathrm{i,t}}$ is the return of company i at time t; $R_{m,t}$ is the market return at time t; $\varepsilon_{i,t}$ is the zero-mean disturbance; α_i is the constant term for company i, and β_i is slope of the characteristic return of company i; $u_{i,t}$ is an independent white noise process with zero mean and unit variance; and $\sqrt{h_{i,t}}$ is a standard error.

For evaluating $R_{\mathrm{i,t}}$, some scholars (Klassen and McLaughlin, 1996; Gupta and Goldar, 2005; Takeda and Tomozawa, 2006) used ordinary least squares (OLS) method. OLS is based on the assumption that the residual ($\varepsilon_{i,t}$) in Eq. is homoscedastic. However, by statistical analysis, it is found that many financial time series (such as the daily return of stock market) take on heteroscedasticity fluctuation. Hence, Engle (1982) put forward the ARCH model (Autoregressive conditional heteroskedasticity model) to depict this kind of series, which can deal with heteroskedasticity. But, to reach an accuracy, the calculating process is very complicated. Then, Bollerslev (1986) put forward the GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) model, which simplified the calculation greatly. The current most widely used is GARCH (1,1). But, the positive and negative impacts of any shocks on conditional variable are always symmetric, which contradicts the reality. Several extensive models are developed to fix this problem, with the EGARCH as the most popular one (Nelson, 1991). The EGARCH model solves this problem by

regressing on the logarithm of conditional variance and by including in the model an asymmetric item. Therefore, the EGARCH (1, 1) model is used in this study.

According to the EGARCH (1,1) model, the $\varepsilon_{i,t}$ in Eq. (1) can be specified as:

$$\log(h_{i,t}) = \omega_i + \gamma_{1,i}\left|\frac{\varepsilon_{i,t-1}}{\sqrt{h_{i,t}}}\right| + \gamma_{2,i}\frac{\varepsilon_{i,t-1}}{\sqrt{h_{i,t}}} + \delta_i \log(h_{i,t-1}) \quad (2)$$

Where

$\varepsilon_{i,t}|\Omega_{t-1} \sim N(0, h_{i,t})$.

ω_i, $\gamma_{1,i}$, $\gamma_{2,i}$, and δ_i are unknown parameters. One of the important advantages of the EGARCH specification is that in Eq. (2), the logarithm of variance $\ln(h_{i,t})$ will be positive, regardless of whether or not the coefficients on the right side are positive.

The abnormal returns ($AR_{i,t}$) are given by taking the estimated returns from the realized returns. Then the cumulative abnormal returns ($CAR_I(t_1, t_2)$) can be calculated by summing the abnormal returns of company i at time t.

$$AR_{i,t} = r_{i,t} - (\hat{\alpha}_i + \hat{\beta}_i R_{m,t}) \quad (3)$$

$$CAR_I(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t} \quad (4)$$

Where, t_1 is when the event window starts, t_2 is when the event window closes

Thus, the cumulative average abnormal return（CAAR）of all the companies can be defined as:

$$CAAR(t_1, t_2) = \frac{1}{N}\sum_{i=1}^{N} CAR_i(t_1, t_2) \quad (5)$$

The third step is to test the statistically significant of abnormal returns. We use J-statistics, which is the value of CAAR divided by its conditional variance, to test the hypothesis that CAAR equals zero.

$$J = \frac{\sum_{i=1}^{N} CAR_i(t_1,t_2)}{\sqrt{\sum_{i=1}^{N} \overline{h_i}(t_1,t_2)}} \sim N(0, 1) \quad (6)$$

When there are many companies, the CAR conditional variance of each stock approximately equals to the squires sum of daily residual within window period.

$$h_i(t_1, t_2) \approx \sum_{t=t_1}^{t_2} AR_{it}^2 \quad (7)$$

The listed energy companies studied in this paper include: production and supply of electricity and heat companies (electricity companies hereafter), coal mining and processing companies (coal companies hereafter), oil and gas exploration companies (oil & gas companies hereafter). The selected companies as the sample studied have the following characteristics: (1) Energy business income accounts for a high proportion (more than 50%) of total income; (2) During the sample period, suspension time is no longer than one month and suspension times is less than three within one year; (3) Only thermal power companies are selected in electricity and heat production and supply industry. According to the criteria above, there are 52 companies are selected from the total 93 listed companies. The statistic results of these companies are shown in Table 2; and the statistic results of these companies daily returns (representing the stock price) are shown

in Table 3. The data is collected from China Stock Market Accounting Research (CSMAR) database and the sample period started from January 1st 2007 to December 31st 2015. Since before 2007, a few important energy companies have not been permitted to be listed, such as China National Petroleum Corporation, China National Offshore Oil Service Corporation, and China Shenhua Energy Corporation, and the market value of these corporation account for more than 60% of the total sample energy listed companies.

Table 2 indicates that thermal power companies account for more than 50% of all the companies with 33. Meanwhile, 36% of the sample companies have a higher level of disclosure while most of the companies have a lower level of disclosure. Larger companies tend to disclose more environmental information. Moreover, more large-scale energy companies locate in eastern areas of China.

Table 3 shows that all listed companies stock prices yields a positive skewness under total environmental policies with 0.0121, which reflects the stock price takes on an increase trend. As can be seen from kurtosis, share returns of all the companies in each environmental policy have the characteristic of peak and thick tail which is consistent with the daily experience of stock prices.

Table 2 Statistical results of listed energy companies

Classification		Number	Market capitalization proportion of top 20 percent companies	Average market capitalization(hundred million of RMB Yuan)
Listed Energy Companies		52	89.10%	473.5
Industry	Electricity, heat production	33	38%	82.4
	Coal Mining	15	71%	292.5
	Oil, gas exploration	4	71%	4378.6
The level of disclosure	High	19	90%	114.6
	Low	33	61%	87.2
Area	East	30	90%	764.2
	Middle	15	48%	88.7
	West	7	33%	52.2
Market capitalization (billion RMB￥)	V<5	22	29.70%	26.4
	5≤V<10	11	25.60%	69.6
	V≤10	19	85.20%	1225.1

Note: The level of EID is classified according to the environmental protection information revealed by the sample companies in their annual social responsibility report. If the following conditions are completely met, a high level of EID is possessed. If not, it is taken as a low level of disclosure. (1) The content of "environmental protection and sustainable development" is mentioned in social responsibility report for at least two consecutive years. (2) At least five contents about "environmental protection and sustainable development" are revealed. (3) Specific pollutant reduction figures are revealed.

"Area" is referred as registration places.

"Scales of companies" is defined by circulation value of companies.

Table 3 Descriptive statistical results of the daily returns of sample companies

Regulations	Mean	Median	Max.	Min.	Var.	Skewness	Kurtosis	N
1	0.0014	0.0000	0.1020	-0.1005	0.0007	0.2595	5.5900	8127
2	0.0048	0.0034	0.1020	-0.1005	0.0012	-0.0672	4.4687	11739
3	0.0048	0.0044	0.1021	-0.1003	0.0013	-0.0922	3.9724	11438
4	0.0044	0.0045	0.1015	-0.1009	0.0014	-0.1180	3.6887	12341
5	0.0013	0.0025	0.1013	-0.1007	0.0017	-0.1021	3.2675	12943
6	-0.0006	0.0013	0.1008	-0.1012	0.0017	-0.0972	3.2702	13545
7	-0.0020	0.0000	0.1017	-0.1007	0.0017	-0.0294	3.2992	12341
8	0.0014	0.0016	0.1014	-0.1016	0.0014	-0.0098	3.6768	14749
9	0.0014	0.0016	0.1016	-0.1013	0.0014	0.0057	3.7289	14749
10	0.0026	0.0023	0.1011	-0.1010	0.0010	0.1397	4.2105	12943
11	0.0010	0.0013	0.1011	-0.1007	0.0009	0.1302	4.6595	13244
12	0.0004	0.0017	0.1013	-0.1000	0.0006	0.3187	5.9187	13545
13	-0.0001	0.0007	0.1012	-0.1000	0.0006	0.2765	5.7859	14448
14	-0.0003	0.0012	0.1010	-0.1008	0.0006	0.2782	5.9257	14147
15	-0.0003	-0.0009	0.1012	-0.1006	0.0006	0.2446	5.9572	13846
16	-0.0002	0.0012	0.1022	-0.1000	0.0005	0.3353	6.1872	12943
17	-0.0008	0.0000	0.1019	-0.0999	0.0004	0.5152	7.2051	13244
18	0.0014	0.0010	0.1011	-0.1011	0.0005	0.5466	7.5699	13545
19	0.0028	0.0027	0.1018	-0.1003	0.0012	-0.1321	5.0511	12642
20	0.0020	0.0034	0.1019	-0.1002	0.0016	-0.2251	4.1464	12943
MBR	0.0004	0.0000	0.1015	-0.1011	0.0006	0.2790	5.8157	22274
Administrative Control	0.0024	0.0020	0.1018	-0.1009	0.0010	0.0670	4.5481	62909

Legislative								
Control	0.0009	0.0011	0.1019	-0.1011	0.0011	-0.0213	4.7094	147791
EID	0.0008	0.0009	0.1010	-0.1010	0.0012	-0.0060	4.3696	26488
All Policies	0.0012	0.0012	0.1017	-0.1016	0.0010	0.0121	4.7512	259462

Note: N stands for the sum of number of observations. The number used for environmental regulation 1 is less than other regulations is that during this event window, the number of companies suffered suspending is more than other periods.

Most of China's listed energy companies are owned by governments. According to the actual controller standard, in all the 52 sample companies, 50 are owned by governments (State-owned Assets Administration Bureau), only 2 are owned by private investors. Figure 1 shows the distribution of shareholding proportion of the listed energy companies owned by governments.

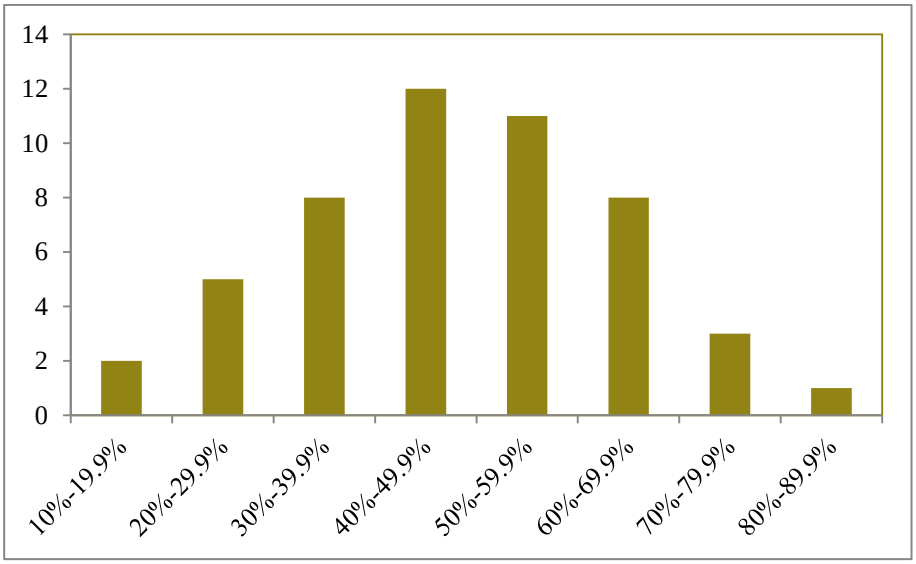

Figure 1: Distribution of shareholding proportion of governments in listed energy companies

5. Results and discussions

The overall impacts of environmental regulations on the stock price of China's listed energy companies are shown in Table 4. Firstly, we concern the comprehensive impact of total "20 policies" on the stock price of listed energy companies (Figure 2). Table 4 and Figure 2 show that from short-term (within 10 days), generally environmental regulation policies have a negative impact on the stock price of China's listed energy companies. This result is similar to Jones and Rubin (2001) conclusion. They found that within two days after the occurrence of these policies, these companies' stock returns fell 0.52%. Moreover, the negative impact takes on a trend of strengthen firstly, and then weakened. Overall, H1 is supported.

Table 4: CAR differences(%) and absolute J-statistics

				Environmental Policies					Industry		The level of disclosure	
estimation window	event window	CAAR/J-ratio	All the companies	Market based regulation	Administrative Control	Legislative control	Information disclosure	Electricity, heat production	Coal Mining	Oil, gas exploration	High	Low
240	[-2,2]	CAAR	-0.015***	0.004	-0.010***	-0.022***	-0.011**	-0.017***	-0.017***	-0.006	-0.021***	-0.012***
		J-ratio	(-7.248)	(0.473)	(-2.793)	(-6.771)	(-2.036)	(-5.742)	(-5.070)	(-0.008)	(-5.813)	(-4.650)
	[-4,4]	CAAR	-0.018***	0.016	-0.017***	-0.029***	0.005	-0.020***	-0.017***	-0.017	-0.022***	-0.016***
		J-ratio	(-6.388)	(1.552)	(-3.555)	(-6.470)	(0.561)	(-5.090)	(-3.636)	(-1.360)	(-4.737)	(-4.401)
	[-6,6]	CAAR	-0.027***	0.014	-0.036***	-0.045***	0.054***	-0.032***	-0.023***	-0.017	-0.033***	-0.024***
		J-ratio	(-7.737)	(0.808)	(-5.390)	(-8.640)	(5.454)	(-6.605)	(-3.979)	(-1.043)	(-5.903)	(-5.206)
	[-8,8]	CAAR	-0.019***	0.019	-0.021***	-0.037***	0.043***	-0.019***	-0.026***	-0.004	-0.023***	-0.017***
		J-ratio	(-5.090)	(1.421)	(-2.949)	(-6.373)	(3.949)	(-3.722)	(-3.894)	(0.061)	(-3.946)	(-3.381)
	[-10,10]	CAAR	-0.015***	0.017	-0.028***	-0.027***	0.048***	-0.013**	-0.024***	-0.025	-0.019***	-0.013**
		J-ratio	(-3.817)	(0.798)	(-3.528)	(-4.261)	(4.062)	(-2.256)	(-3.211)	(-1.132)	(-3.158)	(-2.380)
	[-20,20]	CAAR	-0.008	0.031	-0.014	-0.021***	0.043**	-0.004	-0.026**	0.006	-0.018**	-0.003
		J-ratio	(-1.615)	(1.607)	(-1.322)	(-2.664)	(2.498)	(-0.663)	(-2.318)	(0.732)	(-2.099)	(-0.424)
200	[-2,2]	CAAR	-0.015***	0.003	-0.009**	-0.022***	-0.013**	-0.016***	-0.017***	-0.005	-0.021***	-0.012***
		J-ratio	(-7.189)	(0.390)	(-2.513)	(-6.740)	(-2.252)	(-5.651)	(-5.182)	(0.133)	(-5.851)	(-4.546)
	[-4,4]	CAAR	-0.018***	0.014	-0.016***	-0.028***	0.002	-0.020***	-0.017***	-0.017	-0.022***	-0.016***
		J-ratio	(-6.374)	(1.388)	(-3.352)	(-6.385)	(0.153)	(-5.109)	(-3.623)	(-1.268)	(-4.692)	(-4.419)
	[-6,6]	CAAR	-0.026***	0.011	-0.035***	-0.043***	0.050***	-0.031***	-0.023***	-0.016	-0.032***	-0.023***
		J-ratio	(-7.581)	(0.491)	(-5.207)	(-8.339)	(5.085)	(-6.466)	(-3.944)	(-0.950)	(-5.702)	(-5.167)
	[-8,8]	CAAR	-0.020***	0.014	-0.020***	-0.036***	0.038***	-0.020***	-0.026***	-0.002	-0.023***	-0.017***
		J-ratio	(-5.225)	(1.054)	(-2.841)	(-6.353)	(3.535)	(-3.961)	(-3.849)	(0.214)	(-4.015)	(-3.499)
	[-10,10]	CAAR	-0.016***	0.012	-0.027***	-0.026***	0.043***	-0.013**	-0.025***	-0.023	-0.019***	-0.013**
		J-ratio	(-3.855)	(0.453)	(-3.313)	(-4.175)	(3.590)	(-2.261)	(-3.323)	(-0.999)	(-3.094)	(-2.478)
	[-20,20]	CAAR	-0.007	0.026	-0.011	-0.020***	0.048***	-0.001	-0.028**	0.014	-0.017**	-0.001
		J-ratio	(-1.383)	(1.277)	(-1.015)	(-2.586)	(2.830)	(-0.340)	(-2.568)	(1.202)	(-2.003)	(-0.204)

Note: * = significant at the 10% level. ** = significant at the 5% level. *** = significant at the 1% level.

Table 4 (continue): CAR differences(%) and absolute J-statistics

			State-owned proportion				Area			Market capitalization (hundred million of RMB ￥)		
estimation window	event window	CAAR/J-ratio	10%-30%	30%-50%	50%-70%	70%-90%	East	Middle	West	V<5	50≤V<100	V>100
240	[-2,2]	CAAR	-0.016***	-0.018***	-0.016***	-0.007	-0.017***	-0.016***	-0.007	-0.012***	-0.025***	-0.015***
		J-ratio	(-2.601)	(-5.008)	(-4.858)	(-0.781)	(-6.057)	(-3.853)	(-1.635)	(-3.688)	(-5.378)	(-3.933)
	[-4,4]	CAAR	-0.023***	-0.021***	-0.019***	-0.008	-0.019***	-0.019***	-0.010	-0.017***	-0.026***	-0.015***
		J-ratio	(-2.677)	(-4.179)	(-4.155)	(-0.550)	(-5.333)	(-3.350)	(-1.482)	(-3.975)	(-4.047)	(-3.182)
	[-6,6]	CAAR	-0.032***	-0.033***	-0.026***	-0.013	-0.029***	-0.029***	-0.012	-0.025***	-0.039***	-0.023***
		J-ratio	(-2.940)	(-5.572)	(-4.804)	(-0.487)	(-6.680)	(-3.966)	(-1.477)	(-4.743)	(-4.820)	(-3.987)
	[-8,8]	CAAR	-0.023*	-0.021***	-0.023***	-0.009	-0.022***	-0.023***	0.004	-0.019***	-0.031***	-0.012**
		J-ratio	(-1.937)	(-3.317)	(-3.625)	(-0.038)	(-4.727)	(-3.059)	(0.385)	(-3.369)	(-3.439)	(-2.119)
	[-10,10]	CAAR	-0.019	-0.016**	-0.018***	-0.020	-0.019***	-0.019**	0.007	-0.013**	-0.029***	-0.009*
		J-ratio	(-1.399)	(-2.265)	(-2.652)	(-0.757)	(-3.697)	(-2.324)	(0.653)	(-2.162)	(-2.961)	(-1.682)
	[-20,20]	CAAR	-0.012	-0.006	-0.014	-0.003	-0.009	-0.017	0.011	-0.006	-0.017	-0.004
		J-ratio	(-0.778)	(-0.754)	(-1.374)	(0.301)	(-1.556)	(-1.407)	(0.914)	(-0.839)	(-1.311)	(-0.748)
200	[-2,2]	CAAR	-0.015**	-0.019***	-0.016***	-0.006	-0.017***	-0.016***	-0.007	-0.012***	-0.024***	-0.015***
		J-ratio	(-2.411)	(-5.220)	(-4.750)	(-0.595)	(-5.978)	(-3.857)	(-1.629)	(-3.760)	(-5.239)	(-3.873)
	[-4,4]	CAAR	-0.023***	-0.022***	-0.019***	-0.008	-0.019***	-0.020***	-0.010	-0.017***	-0.026***	-0.015***
		J-ratio	(-2.636)	(-4.421)	(-3.968)	(-0.490)	(-5.237)	(-3.425)	(-1.529)	(-3.990)	(-3.986)	(-3.194)
	[-6,6]	CAAR	-0.029***	-0.033***	-0.026***	-0.012	-0.028***	-0.029***	-0.012	-0.024***	-0.037***	-0.023***
		J-ratio	(-2.700)	(-5.619)	(-4.785)	(-0.388)	(-6.400)	(-4.046)	(-1.509)	(-4.620)	(-4.650)	(-4.003)
	[-8,8]	CAAR	-0.021*	-0.023***	-0.024***	-0.007	-0.023***	-0.024***	0.004	-0.018***	-0.031***	-0.014**
		J-ratio	(-1.756)	(-3.585)	(-3.748)	(0.168)	(-4.784)	(-3.247)	(0.420)	(-3.323)	(-3.447)	(-2.400)
	[-10,10]	CAAR	-0.017	-0.017**	-0.018***	-0.017	-0.019***	-0.019**	0.007	-0.013**	-0.028***	-0.010*
		J-ratio	(-1.294)	(-2.482)	(-2.579)	(-0.507)	(-3.676)	(-2.384)	(0.603)	(-2.249)	(-2.893)	(-1.706)
	[-20,20]	CAAR	-0.008	-0.004	-0.015	0.001	-0.009	-0.015	0.015	-0.004	-0.012	-0.005
		J-ratio	(-0.598)	(-0.534)	(-1.440)	(0.529)	(-1.468)	(-1.273)	(1.156)	(-0.709)	(-0.916)	(-0.824)

Note: * = significant at the 10% level. ** = significant at the 5% level. *** = significant at the 1% level.

Secondly, we wonder the possible different impacts from various types of environmental regulation. Table 4 and Figure 3 show that the negative impact of legislative regulation on the stock price of China's listed energy companies is the largest, and then the administrative regulation generally has the second largest negative impact. The impact of MBR is not statistically significant. Moreover, it is interesting to find that the results estimated for the [-6, 6], [-8, 8], [-10, 10], and [-20, 20] event window for EID are statistically positive. It appears that EID is the most welcome regulation by the stock market. Next to EID, MBR is better than CCR (legislative regulation and administrative regulation) from reducing the shock to stock market. Hence, H2 is supported.

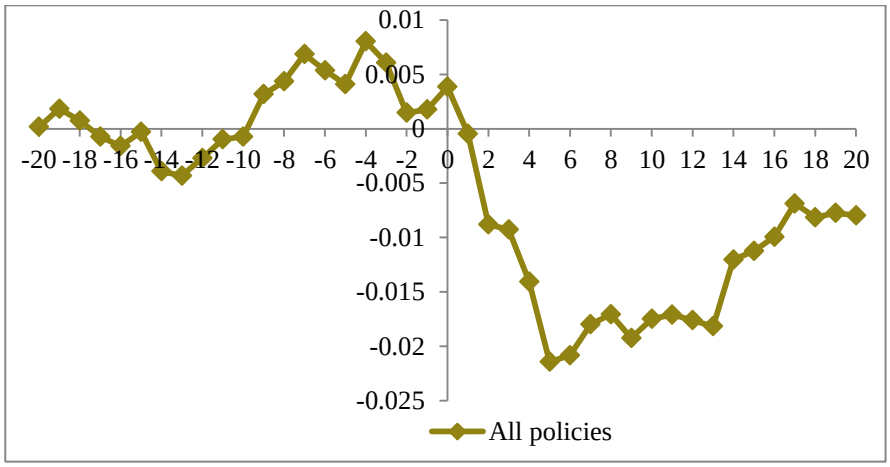

Figure 2 Impact of total environmental policies on the stock price of listed energy companies

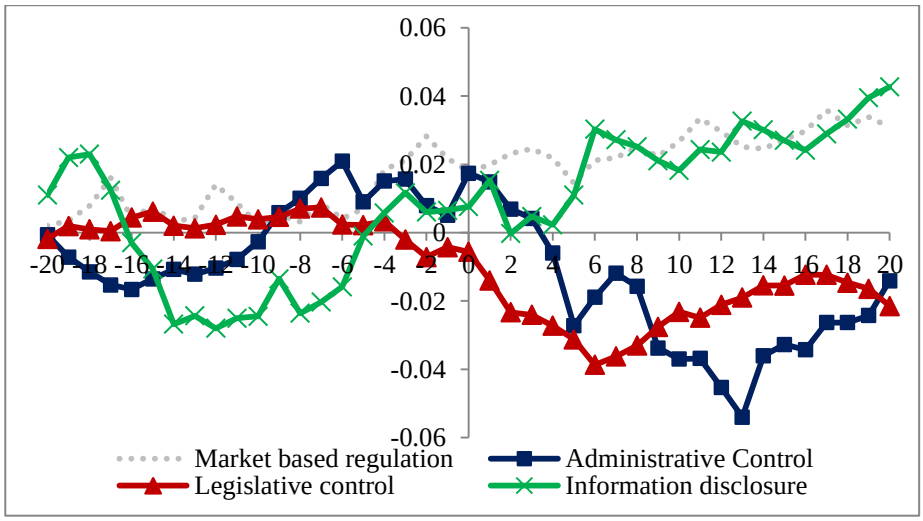

Figure 3: Impact of different environmental policies on the stock price of listed energy companies

Thirdly, we investigated the impact of environmental regulation on the stock price of different energy companies: electricity, coal, and oil & gas companies. As can be seen from Table 4 the results estimated for the [-2, 2] to [-10, 10] event window for electricity companies and coal companies are statistically significant negative; moreover, the negative impact on electricity companies take on a trend of increase firstly, and then

decrease (Figure 4); while for coal companies, the negative impact takes on a trend of increase firstly, and then keeps a relative strong impact. These results imply that stock market has a better confidence for electricity companies to deal with emission control under a new environmental regulation, but it appears that investors have limited confidence for coal companies to control their emission facing a new regulation. It is similar with our expectation that the results for oil & gas companies are not statistically significant. Hence, the above results support H3.

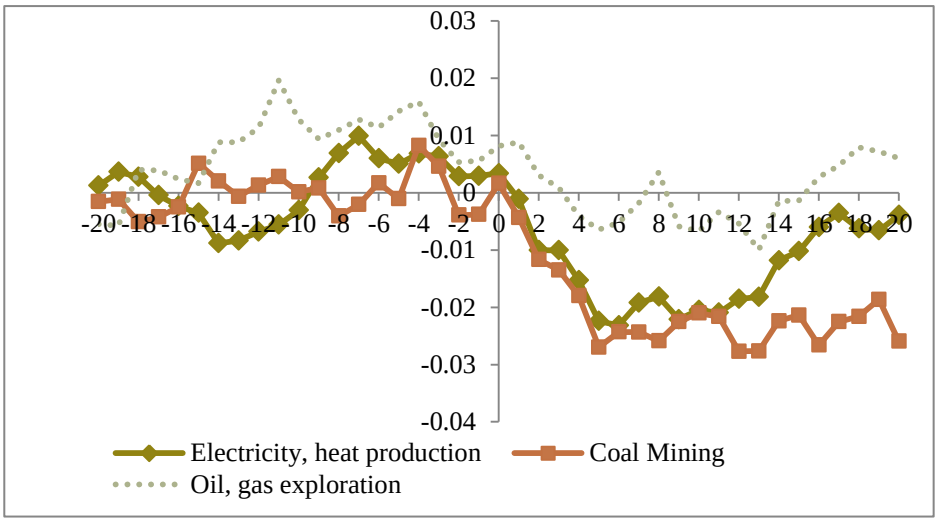

Figure 4: Impact of environmental regulation on the stock price of different kinds of energy companies

Fourthly, with EID has become increasingly popular as an alternative environmental management approach for environmental regulation (Evans et al. 2009; Criado-Jimenez et al. 2008), EID has been paid more and more attention by listed companies. As it is mentioned in Section 4, nearly 40% of the sample listed energy companies have a high level of EID. Here, we want to know whether the difference in EID affect the relations between environmental regulation and the stock price of listed energy companies. Table 4 and Figure 5 show that the results estimated for the [-2, 2] to [-20, 20] event window for the listed energy companies with high level of EID have a statistically significant negative impact, and for those companies with low level of EID, the results estimated for the [-2, 2] to [-10, 10] event window have a statistically significant negative impact. Moreover, the degree of negative impact (CAAR value) for the companies with high level of EID is higher than that with low level of EID. Hence, H4 is rejected. The reasons behind the above results are that the companies with high level of EID have been concerned more by the public, and such information disclosure is thought as a negative news for the company. Whatever, it is an issue need to be concerned that the stock price of energy companies with high level of EID is affected negatively more than those with low level of EID, and this issue is against to promote companies to make EID.

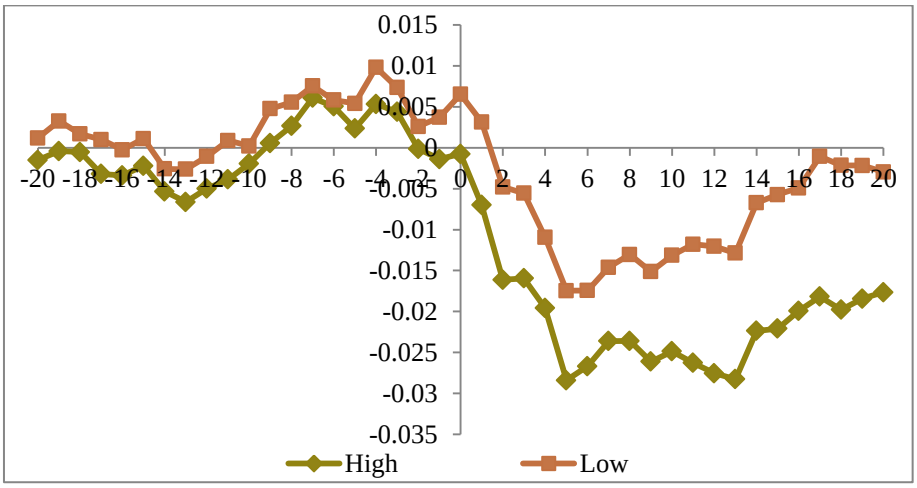

Figure 5: Impact of environmental regulation on the stock price of energy companies with different EID

Fifthly, we intend to explore the impact of ownership of the listed energy companies on the correlation between environmental regulation and stock price. However, since most listed energy companies in China (96.15%) are state-owned enterprises, we can only analyze the impact of different proportions of state-owned shareholdings on the stock price. Table 4 indicates that the companies with more than 70% of state-owned shares, the impact of environmental regulation on the stock price of them is not statistically insignificant; Meanwhile, when the state-owned share is less than 70%, with the decrease of state-owned share proportion, the CAAR of companies with less proportion of state-owned shares dropped quickly, meaning that the negative impact of environmental regulation on the stock price of listed energy companies becomes stronger with the decrease of their state-owned sharehodings (Table 4, Figure 6). Hence, H5 is supported.

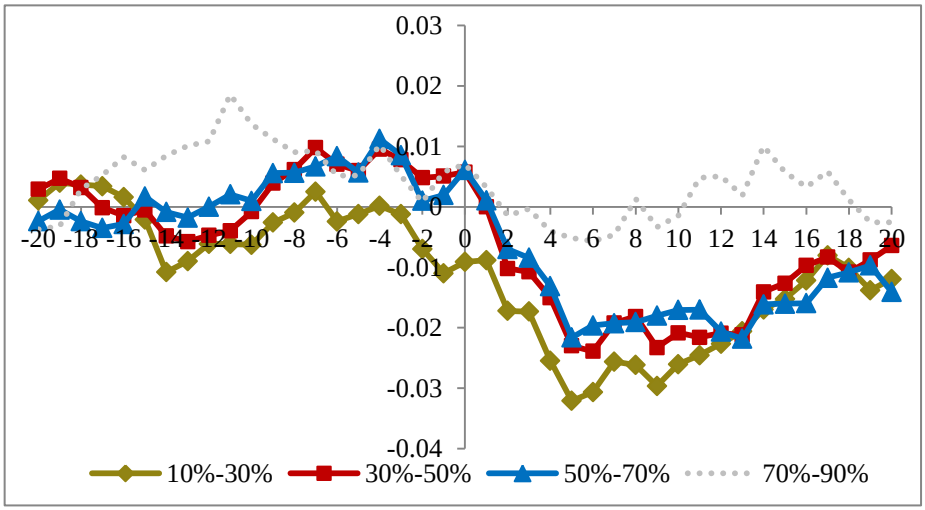

Figure 6: Impact of environmental regulation on the stock price of energy companies with different state share

Sixthly, we want to test the hypothesis of the different impact of environmental regulation on the stock price of listed energy companies in different regions. Table 4 shows that CAAR of eastern and middle regions decreased after the implementation of environmental policies in the event window [-2, 2] to [-10, 10], while, the CAAR of companies in the western regions is not statistically significant. These results imply

environmental regulation has a greater negative effect on the stock price of listed energy companies in eastern and middle regions than that of western regions in China. Hence, H6 is supported.

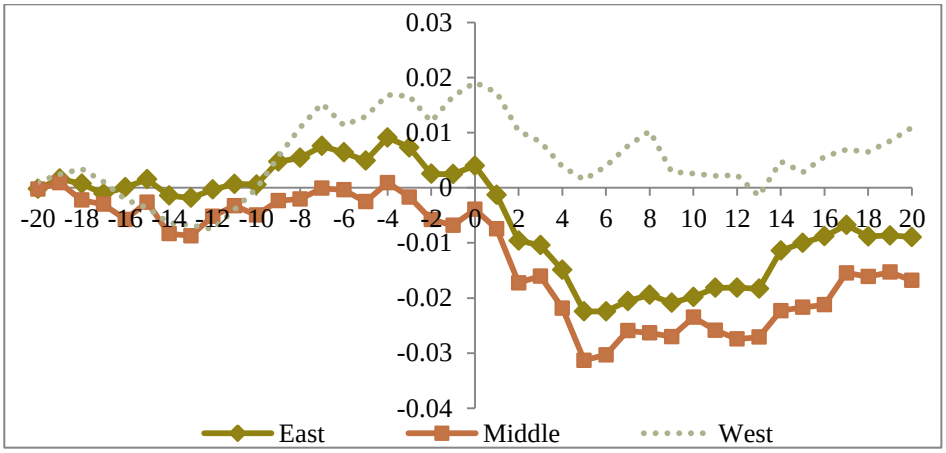

Figure 7: Impact of environmental regulation on the stock price of energy companies in different regions

Lastly, from the ability of dealing with emission control (large-scale companies is strong) and the status of being monitored (small-scale companies is given least attention), we put forward a hypothesis that the listed energy companies with middle-scale is affected negatively most by environmental regulation. Table 4 shows that the CAAR of energy companies with all scales dropped after environmental regulation release (all the stock price of energy companies is affected negatively), but the stock price of energy companies with middle-scale (market capitalization is between 5 to 10 billion RMB￥) dropped greater than that of large-scale and small-scale companies (Figure 8). Hence, H7 is supported.

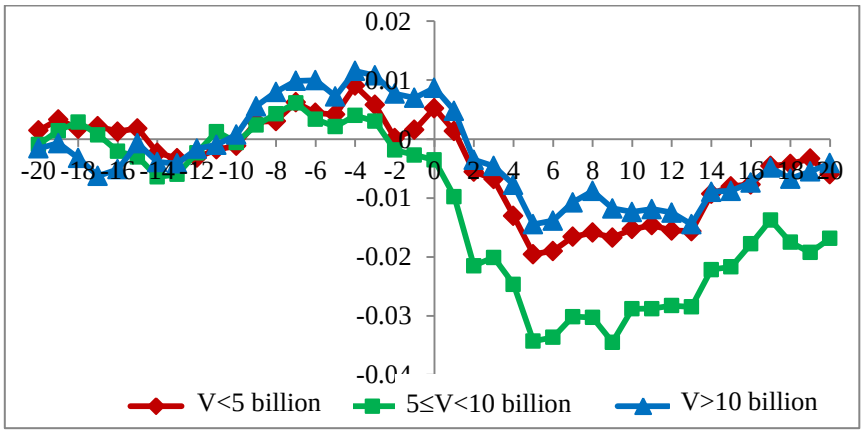

Figure 8: Impact of environmental regulation on the stock price of energy companies with different scales

6 Conclusion and policy recommendations

This paper investigate the impact of environmental regulation on the stock price of listed energy companies considering the differences in policies, sectors, ownership, EID level, regions, and company

scales by using the event study method and EGARCH model. Based on 52 China's listed energy companies (accounting for 55.91% of all listed energy companies) and their daily returns on the stock market from 2007 to 2015, we found that generally, China's environmental regulation has a negative impact on the stock price of listed energy companies in short time. However, such negative impact is caused by legislative and administrative oriented regulation; especially legislative oriented regulation has the most significant negative impact on the stock price of China's listed energy companies. In contrast with CCR (legislative and administrative oriented regulation), the impact of MBR is not statistically significant, which means MBR has little negative shock on the stock price of China's listed energy companies. Meanwhile, an exciting result is that the impact of EID on the stock price of China's listed energy companies is statistically positive for the event window [-6, 6], [-8, 8], [-10, 10]. This result implies that environmental regulation and companies' financial returns can realize two-wins if suitable regulation instruments are chosen.

The third important finding is that environmental regulation has different impact on the stock price of listed energy companies in different sectors in China. Environmental regulation has little impact on the stock price of oil & gas companies, but it has statistically significant negative impact on electricity and coal companies. These results indicates that electricity and coal companies are facing a greater challenge in the front of more and more serious environmental regulations than oil & gas companies.

Meanwhile, by exploring the different impact of environmental regulation on the stock price of listed energy companies with different proportion of state-owned shares, we found that higher proportion of state-owned shareholding, less negative impact of environmental regulation is. And once the proportion of state-owned shares reaches more than 70%, the negative impact is not statistically significant. This result is consistent with our another finding: when listed energy companies scale reaches more than 10 billion RMB ￥of market capitalization, the negative impact of environmental regulation is markedly reduced. These results show that companies' ability of dealing with emission control is an important factor to avoid unfavorable impacts of environmental regulation in short time. However, the ability is not the only factor affecting the relations between environmental regulation and the stock price. We found that small-scale listed energy companies have a less negative impact facing environmental regulation than middle-scale listed energy companies. This is because comparing with middle-scale (or large-scale) companies, small-scale companies have more flexibility in production structure adjustment and have less concern from environmental monitoring.

Another important finding is that in different regions, the impact of environmental regulation on the stock price of listed energy companies is different. The impact of environmental regulation on the stock price of listed energy companies located in western regions is not statistically significant. While, environmental regulation impact for those companies located in eastern and middle regions is statistically significant negative. These results would be caused by two reasons: one is that the economic development level in eastern and middle regions is higher than that in western regions, which lead to the environmental awareness in eastern and middle regions is higher than that in western regions. The other is most industries, including energy industries in western regions are built in recent years, and these new companies faced more serious

environmental regulation standard when they were built, and thus their ability of controlling emission is better than those in eastern and middle regions.

Finally, a seemingly weird finding is that companies with higher level of EID suffer more negative impacts from environmental regulation than the companies with lower level of EID. The main reason for the above result is that after the promulgation of environmental policy, companies have to increase the environmental investment and strengthen environmental management in order to adapt to the EID at the expense of profit. But the enterprises with less EID need not to make a huge investment and then have a less negative impact on their profit. However, the result that the companies with higher level of EID will face a more serious negative impact under environmental regulation is not favorable to motive companies to make more EID, and it unfavorable to realize companies self-control of pollutant emission. Hence, this result causes for worry.

The above conclusions imply a few policy implications to have less negative impact on the stock price of companies in a short time: first of all, EDI and MBR should be given priority to be taken use of. EDI and MBR can encourage companies to voluntarily carry out technical improvement and innovation, as well as they have the advantages of flexibility.

Secondly, it is important to encourage companies to strengthen their ability to deal with emission control by increasing environmental regulation intensity and technological progress. In this study, the companies with higher ability of dealing with emission control are those with more proportion of state-owned shares or with more market capitalization. But, the capital of government can make investment is limited, and the total market capitalization scale is also limited. Hence, the ability improvement of controlling emission can not depend on expanding government investment and market capitalization. The technological improvement of emission controlling or energy saving should become a critical choice. Strengthening environmental regulation and taking use of MBR are affective measures to promote technological innovation (Downing and White, 1986; Milliman and Prince, 1989; Porter, 1990; Porter and Linde, 1995). Hence, once more, we argue that China's policy makers should pay more attention to improve environmental regulation standard by using MBR.

Thirdly, different environmental regulation should be adopted in different regions and different sectors to reduce the negative impact on the stock price of companies. For the eastern and middle regions, with strong capital, high technology, a sound legal system, relatively low regulatory costs, higher level of corporate environmental management and public environmental awareness, it can choose more market incentive and information disclosure policy tools auxiliary to command-and-control policy tools. While in the western areas whose economic level is relatively low, with relative scarcity of capital and technology, lower participation in environment protection of the public, the environmental regulation can depend more on mandatory provisions (CCR) than that in eastern and middle regions. Meanwhile, with the similar reason as the above discussion, in the sector of electricity and coal, EID and MBR should take the lead position in environmental regulation since the companies in these two sectors are sensitive to environmental regulation, and CCR will cause significant negative impact on the stock price of the two sectors. But, the companies in

oil & gas sector are not sensitive to the impact of environmental regulation. Hence, in oil & gas sector CCR can be implemented more than that in the other two energy sectors.

Lastly, but our mostly concern, policy makers should to consider how to motivate companies to make more EID. EID is thought to be an effective way to encourage companies to realize voluntary emission control (Huang and Kung 2010; Kleindorfer and Orts 1998; Jose and Lee 2007). However, this study's result is not favorable to companies to make more EID. Hence, it poses important challenges to Chinese policy makers. By using reward and punish policies, and by making publicity of the companies with good EID to educate the public to get better image and reputation to those companies with more EID.

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