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Stock Market Reactions to Pollution Information Disclosure: New Evidence from the Pollution Blacklist Program in China

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Abstract: Public disclosure of environmental information has been widely used as an important instrument in green finance. In this paper, we examine a blacklist program of polluting firms and conduct an event study to evaluate how the stock market responds to the pollution news. Our results show that the pollution disclosure indeed had a significant negative effect on the stock market performance of listed companies on the blacklists, but only when the overall market was under downward shocks, suggesting that the shareholders were more sensitive to the pollution news in bad times. When the stock market performed well or was relatively stable, the blacklist effects were not evident. Our heterogeneity analyses further revealed that the magnitude of the cumulative abnormal returns depended on the firm size. That is, the larger the firms are, the less they suffer from the pollution news release. Our findings show that pollution disclosure does penalize the polluting firms through stock market response mechanisms.

Keywords: Pollution Blacklist Program; market value; environmental risk; information disclosure; investors

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1. Introduction

With rapid economic growth and heavy dependency on fossil fuel uses, China's environmental issues have become very prominent and curbed future sustainable development. Many listed companies of China have become essential sources of air pollution, which not only create public health hazards to the society but also pose investment risk to investors. Corporate disclosure of environmental information, enabling public access to environmental information and enhancing public participation in environmental regulation, has drawn growing attention from the public.

In recent years, China has already initiated activities on environmental disclosure in environmental regulation. After frequent air pollution apocalypse in the early 2010s, the Ministry of Environmental Protection (MEP) initiated continuous monitoring of major air pollutants in 2013 and legally required the key state-monitored enterprises to release real-time pollution data and disclose them on public online platforms in 2014, which helped improve the system of supervisory monitoring and environmental disclosure and increase public awareness about environmental pollution [1,2].

Based on the online monitoring pollution data of key state-monitored enterprises whose average emissions exceeded pollutant discharge limits, the Securities Times of China and the Institute of Public and Environmental Affairs (IPE) jointly launched a project of "Most Polluted Listed Companies Blacklists (Pollution Blacklist Program)" in January 2015. The most 15–20 polluting companies with the highest environmental risk index (The environmental risk index is a weighted average of the number of days and the average multiples of the firm that exceeded discharge standards during the past week.) were identified with the monitoring data in the past week (Detailed matching processes were

conducted to identify whether the firms on the blacklists were subsidiary or associated firms of listed companies, then the names of both subsidiary or associated enterprises and listed companies were published on the blacklists.) and were published on Securities Times every Tuesday. The Securities Times is a national financial and economic daily newspaper headed by the People's Daily, which is open to the public with a large worldwide audience. This project was terminated on 26 January 2016 (As most monitored listed companies had met the required standards of discharge in January 2016, the program was terminated in February 2016, and the program director said they would design a new monitoring and evaluation approach in the future). From the first official release since 6 January 2015, the entire list included 53 reports and had gotten extensive media coverage.

In many developed countries, pollution information disclosure has been proved effective in improving public awareness and indirectly reducing environmental pollution. In addition, the disclosure of environmental information may affect investors' expectations of the company's future costs and profits, which may lead to changes in the company's stock price. Extensive literature has examined the effects of pollution information on the market value [3–6], however, research is still limited in China. This research contributes to our understanding of how pollution disclosure affects the stock market in China. Since Chinese government has attached great importance to the environmental issues, we expect the announcement of pollution disclosure will bring more investor attention, which will thereby change their trading behaviors. This Pollution Blacklist Program provides a natural experiment for us to explore the relationship between companies' financial performances and pollution disclosure. Using samples of 111 different listed companies included in the blacklists and applying the event study methodology, this paper measures the effect of bad environmental news on stock market performance in China. Our key finding is that the release of the blacklists had some negative impacts on the stock market performance, which indicates that pollution disclosure does penalize the polluting firms through stock market response mechanisms.

What is more, although several studies [7–9] have examined stock market's reaction to disclosure of environmental violations in China, they did not associate the effects with the features of the stock market. In our paper, however, the 53 events studied are extended to one year and one month, during which the stock market experienced wildly swings. By running the models in 4 periods, we investigate the relationship between the effects and the fluctuations of the stock market and find that the magnitude is conditional on the overall stock market performances. The negative effects were only significant in the third quarter of 2015 when the stock market crashed, suggesting the shareholders were more sensitive to the pollution news in bad times. Our results imply that pollution information disclosure may change investment behavior in China, but the effects may be weak if the stock market is stable or in the "bull" market. We also examine the heterogeneity of the relationship between company's characteristic factors and stock market responses and find that the magnitude of the cumulative abnormal returns depended on the firm size.

The paper is organized as follows. Section 2 provides a literature review on the effects of pollution disclosure. Section 3 provides a brief description of data and the event study methodology. In Section 4, we report the results and discuss the findings. Finally, Section 5 offers some concluding remarks and policy implications.

2. Literature Review

Pollution information disclosure has been applied in many countries, for example, the U.S., Canada, Japan, Indonesia and so on. Due to frequent chemical spills in the United States, the U.S. Environmental Protection Agency initiated the Toxics Release Inventory (TRI) program in 1986, requiring manufacturing facilities to disclose information on the annual releases of specific toxic chemicals. Similar programs had been launched in other countries later, for example, Canada's National Pollutant Release Inventory and Japan's Pollutant Release and Transfer Register. As complex information disclosure may affect the public's understanding, many information disclosure projects have chosen environmental

performance rating programs or labeling schemes. A famous example is the Program for Pollution Control Evaluation and Rating (PROPER) in Indonesia. Indonesia implemented the water pollution reduction project PROPER in June 1995, where water polluters were rated in five different color levels based on their environmental performance.

Public disclosure is attractive to policymakers for its low cost, and besides that, information collections are essential for the possible introduction of other policies [10]. It allows the public to monitor the firm's environmental performance and make more informed choices and thereby increases market transparency and reduces market risk [11]. Public disclosure has been proved effective in many projects. For example, the TRI in America, the GreenWatch program in China (The GreenWatch is a public disclosure program in China since late 1998, supported by the World Bank. In this program, firms' environmental performances were rated from best to worst in five colors, i.e., green, blue, yellow, red and black and the rating results are revealed to the public.) and the PROPER in Indonesia have reduced pollutants' emission intensity of firms effectively [10,12,13]. As a regulatory tool, it may reduce pollution in several ways. First, information disclosure itself may be a signal that authorities are becoming serious. Second, environmentally conscious consumers may prefer greener products, some investors will change investors' behavior. Once these emissions were "priced" by stakeholder's response to the disclosure, firms began to reduce pollution [14].

From an empirical perspective, an extensive literature has focused on the impact of environmental information disclosure on the stock market. Different from the conflicting results in research on the effects of positive environmental information disclosure [15–19], most of the researchers found that pollution information disclosure or negative environmental news had a negative impact on the shareholder value [3–6,20–22]. For example, based on the event study methodology, Hamilton [3] found that polluting companies experienced significant negative abnormal returns after the release of TRI information based on data from 463 U.S. companies. He explained that this may be due to investors' view of TRI as a sign of the company's low production efficiency, reflecting the poor performance of the company's management and potential accident risks. What is more, investors believed that companies in the TRI would face pressures from institutions and governments, such as the government's punishment and the requirement of purchase of new emission reduction equipment. Khanna et al. [23] extended Hamilton's sample and reached similar conclusions.

Previous analyses are mainly based on pollution disclosure in developed countries. As the world's largest developing economy, China's pollution disclosure and its influence on the stock market has been paid special attention. Xu et al. [7] found that the listed companies experienced a significant decline in market value following the disclosure of environmental violations and the average reduction was much lower than the changes in market in developed countries and other developing countries. Xu et al. [8] further showed that companies with environmental violation events generally suffered greater losses when they attracted higher levels of media attention. In a recent paper, Zhou and Yin [9] focused on the effects of "List of public companies causing significant environmental risks" program and found that China's stock market penalizes companies after revelation of negative environmental news.

In this study, building upon the limited research of Chinese pollution information disclosure, we conduct an event study to examine whether or not the stock market in China reacted to the releases of weekly pollution blacklists. Departing from most previous studies that has primarily focused on the impact of pollution disclosure on the stock returns, this paper also investigates the relationship between the effects and the fluctuations of the stock market. In addition, this study is based on the online data of monitored firms and the pollution disclosure is mainly external events, so there are no self-selection biases that are common in many literatures.

3. Data and Methodology

3.1. Data

We collected the information of polluting companies in the 53 issues of blacklists released by the Securities Times and IPE from January 2015 to January 2016. The disclosure information of the blacklists included names of publicly listed companies, stock symbols, pollutants, environmental risk indexes and so on, which were published on Securities Times every Tuesday and were carried widely by a number of other influential media outlets. When the blacklists were released, the Securities Times also provided detailed interpretations on the overall environmental status of these companies.

Over the entire period, a total of 111 distinct listed companies had been revealed in the 53 blacklists, which were distributed in 20 industries, mainly in the public utilities, chemical and building materials industries, as shown in Figure 1.

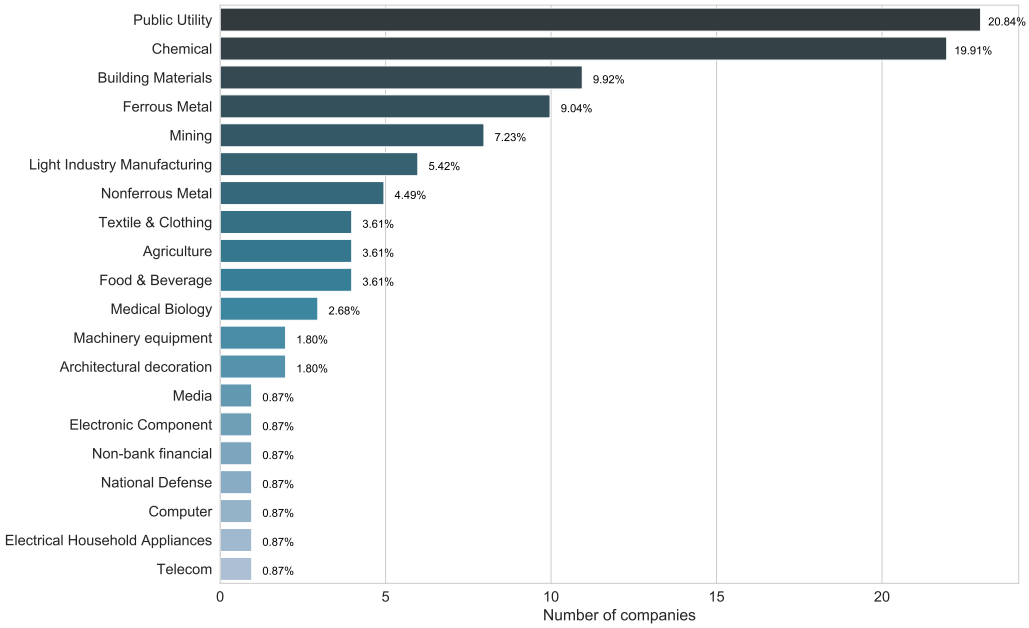

Figure 1. Frequency distribution of companies in the blacklists across industries.

Table 1 presents the pollution information of companies in the blacklists for each month, including the number of event companies (The same company may appear on the blacklists more than once), the number of days that exceeded the discharge standard and the environmental risk index. As shown in Table 1, the number of companies listed in most months is between 70 and 90 (Due to the statutory holidays of China, only two lists were issued in February and October 2015, thus the number of companies on these two lists were relatively small). In terms of the average environmental risk index, it was higher in the initial and mid-term period of the lists, then it began to decline in later months. For example, the environmental risk index reached an average number of 65.8 points in February 2015 and 59.52 points in June 2015, while it decreased to 52.75 points in January 2016. The number of days exceeding the pollution discharge also showed a downward trend over time, while the average multiples and maximum multiples of exceeding discharge standard for polluting companies did not decrease with time.

Table 1. Pollution information of companies on the blacklists.

Year and Month	Number of Event Companies	Days of Exceeding Discharge Standard	Average Multiples of Exceeding Discharge Standard	Maximum Multiples of Exceeding Discharge Standard	Environmental Risk Index
201501	71	4.73	1.28	1.81	59.29
201502	53	5.49	1.41	1.73	65.8
201503	70	4.43	1.12	1.89	51.58
201504	72	4.67	1.39	1.89	59.5
201505	74	4.31	1.32	1.84	55.31
201506	93	4.39	1.45	1.84	59.52
201507	75	4.53	1.38	1.82	55.8
201508	72	4.04	1.34	1.69	52.76
201509	91	3.98	1.25	1.64	51.36
201510	45	4.04	1.65	2.6	57.64
201511	71	4.3	1.28	1.59	52.06
201512	91	3.88	1.37	2.01	53.06
201601	54	3.63	1.41	2.18	52.75

The data of stock prices of the Chinese listed companies were collected from the Wind database. We also collected data of firm characteristics from the Wind database, including ownership types, the number of employees and so on. The ownership types of listed firms in the Wind database are divided into three categories, namely, central state-owned enterprises, local state-owned enterprises, private and other enterprises.

After collecting the data of sample companies, we then dropped some observations based on the following rules: (1) Companies that have the risk of stock termination (i.e., ST companies); (2) companies that have been suspended from trading for more than 60 days during the estimation window; (3) companies that have been suspended from trading during the event window. After the above cleanup, a total of 767 research samples were obtained, covering 53 events (53 list releases).

Table 2 presents the financial and other characteristics of the sample companies in 2015. The average number of employees of the sample companies was 43,600. Most were local state-owned, private or other types of firms. The average environmental risk index was 55.04, with the largest risk index reaching 100 and the lowest 7.64.

Table 2. Summary statistics of sample companies.

	Mean	Std	Min	Max
Number of samples	767	-	-	-
Revenue(100 million yuan)	1610.29	5484.99	6.56	28,259.1
Employee(Ten thousand people)	4.36	11.68	0.04	53.47
Ownership Type	1.99	0.75	1	3
Environmental Risk Index	55.04	27.64	7.64	100

Note: Ownership type represents ownership of the company, where 1 represents the central state-owned firms, 2 represents the local state-owned firms, 3 represents the private and other types of firms.

3.2. Methodology

This paper employs the event study methodology to evaluate the stock price reaction to pollution information news. The event study methodology was originally applied in finance to analyze the impact of specific events on stock prices [24]. The basic idea is that the impact of new information will be reflected in changes of short-term stock market prices when the capital market is efficient [22]. This allows for identifying the effect of pollution disclosure on the firms' market value.

We adopt the market model introduced by MacKinlay [25]. The market model predicts normal returns with Ordinary Least Squares (OLS) that regresses stock returns on

market returns over the estimation window. For any stock i, the market model has the following form:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}, \quad (1)$$

where R_{it} is the actual return of stock i at time t, and R_{mt} refers the return of the market portfolio m at time t. In practice, R_{mt} is usually a weighted-average return containing a series of stocks. In most of the event studies, researchers use the return of all stocks as the market return [9,18,21]. However, King [26] and Marks [27] confirmed that an industry index would be more informative and produce more powerful tests than a national index that only reflected the average effect on all firms. In our paper, the industry's return rate is chosen as representative of the market return rate (calculated based on the daily industrial stock market indices, i.e., the SW Primary Sector Indices and the CITIC Primary Sector Indices (The SW Primary Sector Classification was created by Shenyin & Wanguo Securities Research Co., Ltd. and the CITIC Primary Sector Classification was created by CITIC Securities, which are both widely used to classify over 3000 publicly listed companies in China and are also the basis of SW Primary Sector Indices and CITIC Primary Sector Indices)).

The company's daily actual returns are calculated as:

$$R_{it} = \frac{P_{it}}{P_{it-1}} - 1, \quad (2)$$

$$R_{mt} = \frac{P_{mt}}{P_{mt-1}} - 1, \quad (3)$$

where P_{it} and P_{it-1} are the current day's closing price and the previous day's close price of the stock, respectively. P_{mt} and P_{mt-1} are the closing prices of the current day and the previous day of the industry where the company belongs to.

Equation (1) is generally estimated in the estimation window, which is a period prior to the event day (usually sized 120–300 days).The event day is defined as Day 0 and the other days before or after the event can be defined by differences from the event day. In this study, we set the estimation window period $[-210,-10]$, which means between 210 and 10 days before the event. The event window is a period around the event announcement. With the parameters $\hat{\alpha}_i$ and $\hat{\beta}_i$ estimated from Equation (1), we can calculate the normal return for the event window:

$$\mathrm{NR}_{it} = \hat{\alpha}_i + \hat{\beta}_i R_{mt}. \quad (4)$$

The abnormal return AR_{it} is the difference between the actual return and the normal return for each firm and day during the event window. The abnormal return for individual stock i at time t is defined as:

$$\mathrm{AR}_{it} = R_{it} - \mathrm{NR}_{it}, \quad (5)$$

We define the cumulative abnormal return (CAR) from time τ_1 to τ_1 ($T_1 < \tau_1 \leq \tau_2 < T_2$, where T_1 and T_2 are the lower bound and upper bound of the event window, respectively) as $\mathrm{CAR}_i(\tau_1, \tau_2) = \sum_{\tau_1}^{\tau_2} AR_{it}$.

Then we aggregate the cumulative abnormal return across all events during the study period and get the cumulative average abnormal return (CAAR). The CAAR for N events in time τ_1 to τ_2 is defined as:

$$\mathrm{CAAR}(\tau_1, \tau_2) = \frac{1}{N} \sum_{i=1}^{N} \mathrm{CAR}_i(\tau_1, \tau_2) \quad (6)$$

We need to further test whether the CAAR is significantly different from zero. The null Hypothesis 1 and alternative Hypotheses 2 in this study are as follows:

Hypothesis 1. *The releases of the pollution blacklists have no significant impact on market values of the listed companies.*

Hypothesis 2. *The releases of the pollution blacklists have a significant impact on market values of the listed companies.*

In order to test the null hypothesis that the stock market does not respond to pollution news, we formulate a Z test introduced by MacKinlay [25]. The variance of CAAR and Z-statistics are expressed as follows:

$$\mathrm{var}(\mathrm{CAAR}(\tau_1, \tau_2)) = \frac{1}{N^2} \sum_{i=1}^{N} \sigma_i^2(\tau_1, \tau_2), \tag{7}$$

$$Z = \frac{\mathrm{CAAR}(\tau_1, \tau_2)}{\mathrm{var}(\mathrm{CAAR}(\tau_1, \tau_2))^{1/2}}. \tag{8}$$

The most common event window in the literature is usually selected within 1 to 5 days around the event. As there is possibility of potential information leakage prior to the events, we will conduct the analyses based on two kinds of event windows, i.e., [−1,1], [−2,2], [−3,3], [−4, 4] when considering the existence of information leakage and $[0, 1]$, $[0, 2]$, $[0, 3]$, $[0, 4]$ when not considering the existence of information leakage.

4. Empirical Results

This section reports the results of this study. First, we focus on the effects of Pollution Blacklist Program throughout the whole period. Then we further segment the whole period into four sub-periods and examine the effects by periods. Finally, we extend our analysis by investigating the determinants of cumulative abnormal returns base on a cross-sectional analysis.

4.1. Results throughout the Entire Period

We begin with our main results assessing the effects of 53 blacklist releases on shareholder value throughout the entire program period from January 2015 to January 2016. Table 3 reports the CAAR during different event windows based on the event study methodology.

Table 3. Main results on CAAR throughout the entire period.

Event	SW Primary Sector Index		CITIC Primary Sector Index	
Window	**CAAR**	**Z-Statistics**	**CAAR**	**Z-Statistics**
Considering the leakage of information				
[0]	−0.0024 ***	−2.6116	−0.0023 **	−2.5410
[−1, 1]	−0.0037 **	−2.3459	−0.0030 *	−1.8957
[−2, 2]	−0.0021	−1.0290	−0.0031	−1.5427
[−3, 3]	−0.0012	−0.5019	−0.0043 *	−1.7943
[−4, 4]	−0.0016	−0.5926	−0.0042	−1.5486
Not considering the leakage of information				
[0]	−0.0024 ***	−2.6116	−0.0023 **	−2.5410
[0, 1]	−0.0039 ***	−3.0497	−0.0033 ***	−2.5954
[0, 2]	−0.0029 *	−1.8453	−0.0033 **	−2.1098
[0, 3]	−0.0025	−1.3808	−0.0041 **	−2.2828
[0, 4]	−0.0009	−0.4468	−0.0024	−1.1874

***, ** and * indicate significance at the 1%, 5% and 10% levels. CAAR denotes the average value of the cumulative abnormal return (CAR).

We first investigate the effects of information leakage on trading behavior. The results are shown based on SW Primary Sector Indices and CITIC Primary Sector Indices. According to Table 3, the stock market has a negative reaction to the releases of pollution blacklist in the short time. The CAAR based on SW Primary Sector Indices is −0.0023 on

the event day, which is smaller in magnitude than the effects of similar programs in the extant literature (as shown in Table 4), and becomes −0.0037 over the event window [−1,1]. As time goes, the impact fades away quickly. The results are robust when using CITIC Primary Sector Indices.

Results remain substantially unaltered when information leakage around events is not considered. The CAARs under the two industry indices are −0.0039 and −0.0033 over the event window [0, 1], respectively. When the CITIC Primary Sector Indices are adopted, this negative impact will continue until three days after the release of the list.

We further calculate the impact of the news on the change in firm market value in a specific case of Kailuan Energy Chemical Co., Ltd. In 7 July 2015, Kailuan Energy Chemical Co., Ltd., a coal enterprise located in Hebei province, was placed on the blacklist for excessive emission of sulfur dioxide, with the environmental risk index reaching 100. The CAR of this firm on the event day is −0.056. According to Klassen and Mclaughlin [4], this loss translates to a change of 448.7 million RMB in market capitalization of this firm on the event day.

Overall, the release of environmental risk blacklist has a significant negative effect on the market value in the short term, indicating that investors respond negatively to the stock market when the blacklists released. The reason may be that the disclosure of environmental pollution information of publicly listed companies can help the public to understand the companies' environmental pollution status and identify their potential environmental risks, which leads to a lack of confidence of investors and thus affecting their investment behavior, as is the case for Qingshan Paper Company for instance. After the disclosure of excessive emission of nitrogen oxides of Qingshan Paper Company in three consecutive blacklists, together with the interpretation which pointed out that technical transformation project of 3.2 billion funds had a potential hazard to the environment, there was a sharp fall in the stock price on the event day after two consecutive days of gains. Stock prices of Qingshan Paper did not recover until it gave a detailed response to the over-standard discharge of pollutants and technical transformation project problem for the second time [28].

Table 4. Studies on pollution disclosure or envionmental violations employing event study methodology.

Studies	Events and Year	Country	Effect on the Event Day
Xu et al. [8]	Environmental violation, 2007–2011	China	−0.0052
Zhou and Yin [9]	Pollution disclosure, 2015	China	−0.0069
Dasgupta et al. [21]	Environmental violations, 1993–2000	Korea	−0.097 [a]
Gupta and Goldar [29]	Environmental rating, 2001–2002	India	−0.0152 [b]
Hamilton (1995) [3]	Pollution disclosure, 1989	USA	−0.0028

[a] This paper shows that 47 of the 87 events studied have significant negative market reactions, the effect of −0.097 is for those events with negative market reactions. [b] The result of −0.0152 is over the event window [0, 1].

4.2. Results by Sub-Periods

The program had released 53 blacklists over 13 months, during which the stock market had intense fluctuations. In order to relate the effects to the performance of the stock market, we explore the impact of the blacklist releases on the market value of listed companies by 4 sub-periods in this section. After dividing the whole period from January 2015 to January 2016 into four time segments, i.e., 2015Q1 (the first quarter of 2015), 2015Q2 (the second quarter of 2015), 2015Q3 (the third quarter of 2015) and 2015Q4 & 2016M1 (the fourth quarter of 2015 and the first month of 2016), we perform the event study described above by four sub-periods.

Table 5 reports the results based on the SW Primary Sector Indices (Results based on CITIC Primary Sector Indices are similar). The first row of Table 5 shows that the CAARs for each sub-period on the event day are −0.0018, −0.0028, −0.0057 and −0.0008, respectively, and the results are statistically insignificant except in the third period (July

to September in 2015). The CAAR over the event window [−1,1] reaches −0.0116 and is significant at the 1% level in the third period.

The results show that the stock market does not respond to the news for most of the study period. This may due to the low penalties and weak enforcement of environmental statutes and regulations. China's New Environmental Protection Law, which was implemented on 1 January 2015, stipulated measures for daily punishment for environmental violations, which however, did not form a major deterrent for enterprises. According to the 2015 summary report of this program [28], only nearly 40% of the firms on the blacklists suffered environmental regulation or punishment and some firms even chose to ignore environmental penalties and continued to discharge excessive emissions, which indicated that local environmental protection departments had weak enforcement of environmental laws and the violation costs were rather low. For example, in August 2015 China National Water Corporation had received 10 million in fines for over-standard emission, but it still discharged pollutants that exceeded acceptable levels and kept appearing on the blacklists after the fines. Therefore, environmental penalties did not provide enough incentives for some firms to reduce pollution emissions. The investors may also not treat this as a big problem and do not pay much attention to the pollution news most of the time.

Table 5. Main results on CAAR by sub-periods.

Event	**2015Q1**		**2015Q2**		**2015Q3**		**2015Q4 & 2016M1**	
Window	**CAAR**	**Z-Stat**	**CAAR**	**Z-Stat**	**CAAR**	**Z-Stat**	**CAAR**	**Z-Stat**
[0]	−0.0018	−1.2866	−0.0028 *	−1.7618	−0.0057 ***	−2.7035	0.0008	0.3994
[−1, 1]	−0.0025	−1.0299	−0.0032	−1.1710	−0.0116 ***	−3.1557	0.0024	0.7235
[−2, 2]	−0.0015	−0.4900	−0.0036	−1.0220	−0.0033	−0.6858	0.0000	0.0090
[−3, 3]	−0.0040	−1.0708	−0.0066	−1.5804	0.0070	1.2390	−0.0016	−0.3129
[−4, 4]	−0.0042	−0.9934	−0.0110 **	−2.3275	0.0075	1.1846	0.0007	0.1307
Observations	163		199		196		209	

***, ** and * indicate significance at the 1%, 5% and 10% levels.

It is also shown that the effect of pollution news is significant during the third quarter of 2015. This reveals that the reaction to releases of blacklists varies at different periods, depending on the performances of the stock market. By reviewing the stock market of the study period, we find that the Shanghai Stock Exchange (SSE) Composite Index (SSE Composite Index is a stock market index of all stocks listed on Shanghai stock exchange, which is commonly used as indicative of stock market trends of China) experienced a continuous rise during the first half of 2015, at one point hitting 5178 on 12 June 2015, resulting in the increasing investment enthusiasm. However, after the buying frenzy, the stock market suddenly crashed with the bursting of the stock market bubble in middle June 2015. From then on, the market had been plunging and investors fell into panic. On the 26th of August, the SSE Composite Index reached the lowest point of 2015. Overall, the first and second stock markets experienced "thousands of stocks skyrocketing", while the stocks crashed 28.6% in the third quarter. In the fourth quarter of 2015 and the first month of 2016, the market was relatively stable. Figure 2 exhibits SSE Composite Index during January 2015 to January 2016. Linking the performance of the stock market with the effects of the pollution news announcements, it may be that when the market performs well or is relatively stable, such as the first half and the fourth quarter of 2015, investors may be more speculative and less concerned about the company's negative environmental information. The releases of blacklists have little effect on the investment decision of shareholders during those good times. However, when the market generally performs poorly, investors have low expectations and tend to make more risk-averse investment choices. Therefore, environmental risk of listed companies will be taken into consideration, which lead to a negative reaction to pollution disclosure.

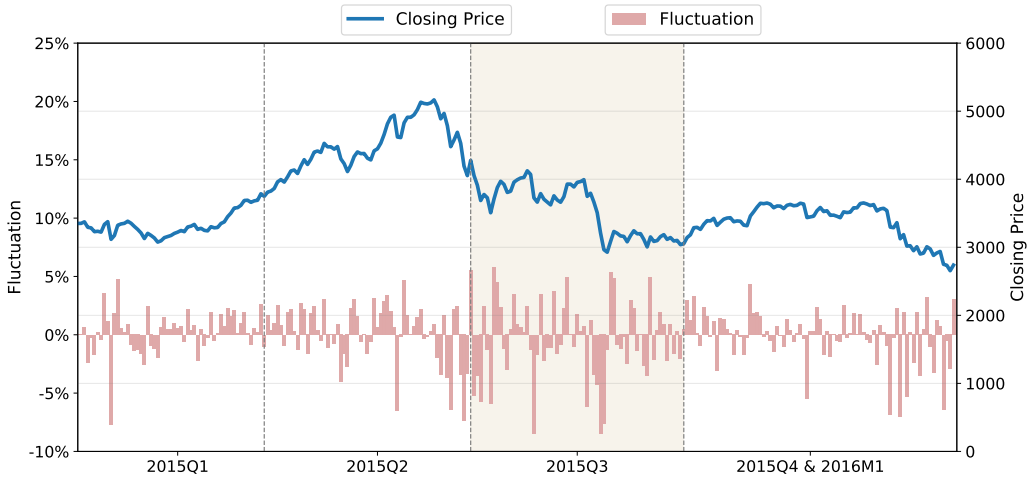

Figure 2. SSE Composite Index between January 2015 and January 2016. Source: The daily closing price is collected from the Wind database. Daily fluctuation is measured by the percentage change in closing prices of the current day and the previous day.

4.3. Heterogeneity Analysis

The preceding evidence suggests that the release of pollution blacklists resulted in a reduction on stock market returns. In this section, we extend the analysis by exploring what factors may affect the market returns, including firm characteristics such as size, ownership type and variables related to the blacklists such as environmental risk and the number of appearances of the firm on the blacklists. Our regression model is as follows:

$$\mathrm{CAR}_i = \beta_0 + \beta_1 type_i + \beta_2 size_i + \beta_3 \ln risk_i + \beta_4 num_i + \varepsilon_i \quad (9)$$

where the dependent variable is the cumulative abnormal return for stock i over the event windows [0], [−1, 1] and [−2, 2]. $Size_i$ is the company size, which is defined as the natural logarithm of the number of employees; $type_i$ is the ownership type of the company; $risk_i$ is the natural logarithm of the company's environmental risk index. In addition, we also include the variable num_i, which indicates the number of times the company has appeared in the lists. ϵ_i is the residual term. The regression results are shown in Table 6.

As seen in Table 6, firm size is significantly positive at 5% level for the event day, suggesting that the market values of larger firms suffer less reduction as the CARs are generally negative values. This may be due to that investors expect larger firms are more inertial to pollution news and can perform better, for larger firms have more experience and greater capabilities to recover from a loss in the stock market when facing difficulties [30].

As the names are listed on the blacklists by environmental risk index from high to low, which conveys distinctive features of these firms, we examine whether the environmental risk index affects behavior of the investors. The results show that the CAR is not associated with the level of company's environmental risk index, meaning that the higher environmental risk does not lead to a higher reduction of market value.

We also find that the number of times appeared on the blacklists has no significant effect on the CAR, which is different from Zhou and Yin [9]. According to [9], as the investors fully realized the bad news, the stock market would be less susceptible to the pollution disclosure. However, our research results show that the frequent appearances of companies on the blacklists do not reduce investors' informed expectations and have no significant impact on the company's cumulative abnormal returns.

Table 6. Regressions of CAR.

Variables	(1) CAR [0]	(2) CAR [−1, 1]	(3) CAR [−2, 2]
type_1	0.0105	0.0240 *	0.0273 *
	(0.0066)	(0.0125)	(0.0148)
type_2	0.0136	0.0113	0.0083
	(0.0084)	(0.0159)	(0.0187)
size	0.0036 **	0.0035	0.0016
	(0.0015)	(0.0029)	(0.0034)
lnrisk	−0.0043	0.0022	0.0026
	(0.0040)	(0.0077)	(0.0091)
num	0.0004	0.0023	0.0007
	(0.0008)	(0.0015)	(0.0018)
Constant	−0.0827 **	−0.1252 *	−0.0667
	(0.0351)	(0.0668)	(0.0787)
Observations	196	196	196
R-squared	0.032	0.045	0.027

Within brackets are the values of standard deviations. ** and * indicate significance at the 5% and 10% levels.

5. Conclusions and Policy Implications

Pollution disclosure, as an important tool for environmental regulation, has been used more extensively in China in recent years. The Pollution Blacklist Program initiated by the Security Times and IPE during January 2015 to January 2016, was just one typical application. Based on the event study methodology, this paper examined the market reactions to this program. The results indicate that during the whole period, the releases of the pollution blacklists had a significant negative impact on the market value of the listed companies in the short-term, and the effects gradually faded away in the long-term.

Furthermore, by dividing the samples of the whole period into 4 time segments and conducting the analysis by periods, we find that the effects are related to the volatility of the stock market. More in detail, for the firms that appeared on the blacklists in the third quarter of 2015, during which the market generally performed poorly and had intense violations, the pollution disclosure had a significant negative impact on market value. For the firms that appeared on the blacklists in other periods, during which the market performance was relatively good or stable, the impact was not significant.

Moreover, we analyzed the determinants of the company's cumulative abnormal returns and found that cumulative abnormal returns are mainly determined by the company size, while the environmental risk index, the number of times that the firm appeared on the lists and other factors are not correlated to the company's cumulative abnormal returns.

Our results have several important policy implications for practice. First, pollution disclosure is a useful instrument for environmental regulation. As shown in this paper, information disclosure may change investors' expectations to some extent. The stock prices of listed companies had been negatively affected in the short-term. Due to the downward pressure on stock prices, the company may also have incentives to reduce pollutant emissions.

Second, harsher punishments for polluters are critical for efficient environmental regulation. The results show that there is a slight reduction of market returns after the release of blacklists, which suggest the low environmental penalty and weak enforcement of environmental laws in China. The enterprises that comply with the environmental statutes and regulations cannot be effectively protected or compensated, which may lead to more environmental violations in the long run. Therefore, the governments should strengthen the penalties for violations to ensure compliance with environmental regulations.

Finally, the NGOs and the public can play positive roles in information disclosure. The Pollution Blacklist Program discussed in this paper was initiated by the Securities Times and the Environmental NGO, and further affected the market value of the listed

companies by influencing the decision of the investors. Providing the public pollution information enables them to make effective decisions. Therefore, not only the government and enterprises, but other entities such as the NGOs, media and the general public can participate in environmental regulation and environmental disclosure. With public scrutiny and participation, the environmental issues can be best handled [31].

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