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Original Research

Environmental Incidents, Policy Regulations, and Capital Market Reactions: Evidence from the "Cadmium Rice" Event in China

Fan Zou*

College of Economics & Management, Nanjing Agricultural University, Nanjing 210095, China

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Abstract

Heavy metal contamination, which has received increased attention recently, adversely affects food safety by damaging soil and crop quality. In an environmentally concerned and efficient stock market, a negative environmental pollution incident will shock the stock prices of the companies involved. This paper uses the short-term event study approach to analyze the capital market reaction to a prominent heavy metal pollution incident in China, the 2013 "cadmium rice" event, and the subsequent policy regulations. Our findings show that listed companies in heavy metal industries experience significant negative abnormal stock returns during the "cadmium rice" event window. The market reacts weaker to subsequent policy regulations than to the incident itself. Significant negative abnormal stock returns can only be observed during the event window of legislation or regulative policy explicitly mentioning sanctions against companies. Strong past environmental performance by companies and greater media attention, which suggests fewer investor concerns regarding potential pollution punishment, can mitigate negative market reactions. Conversely, stricter regional environmental regulations may exacerbate these negative reactions. These findings confirm the effectiveness of capital markets in developing countries and underscore the significance of company environmental performance, particularly in light of environmental incidents concerning food safety. Meanwhile, strengthening the implementation of environmental policies, coupled with media monitoring, is necessary to control heavy metal pollution.

Keywords: environmental pollution incident, environmental regulations, cadmium rice, capital market reactions

Introduction

As the economic growth of developing countries increases, several environmental issues have become more prominent [1]. Among various environmental problems, soil heavy metal pollution has received significant attention from government departments and society due to its long-term, cumulative, latent, and irreversible nature [2]. In 2013, Guangdong Province of China revealed that a large amount of rice on the market exceeded the cadmium standard, highlighting the problem in which more than one-sixth of the country's arable land was contaminated with heavy metals and crops were absorbing these elements [3]. Following this,

*e-mail: zoufan0921@qq.com;
Tel.: +86-13222437838

the "cadmium rice" crisis spread across China. As of 2022, there is still a significant amount of agricultural products, such as "cadmium rice," heavily contaminated on the market [4]. Most heavy metal elements in the soil come from wastewater and gases released during the production processes of heavy pollution industries, such as nonferrous metal extraction and smelting [5]. As a result, these businesses have become the primary cause of the "cadmium rice" event.

As public awareness of environmental issues like heavy metal pollution grows, it becomes crucial to harness the potential of capital markets in pollution management. Negative environmental incidents such as the "cadmium rice" event can signal to investors that the government may enforce stricter environmental regulations or enhance existing policies, leading to internalizing external costs associated with pollution in production and ultimately resulting in profit reduction [6]. Therefore, when heavy metal pollution incidents are exposed, investors may incorporate the economic consequences of environmental factors into their decision-making process, thereby reassessing the valuation in enterprises involved in heavy metal pollution. As stakeholders of enterprises, investors' "voting with their money" behavior indirectly penalizes companies for their polluting actions, incentivizing them to enhance their environmental performance [7]. In developing countries with limited government resources, capital markets can serve as a beneficial supplement to government environmental regulation [8].

However, the literature on the response of developing countries' capital markets to environmental pollution incidents is minimal. Numerous studies have been conducted to investigate the economic impact of environmental pollution incidents, drawing on evidence from developed capital markets. They discovered that negative environmental events such as air pollution, climate risk, and mining spills can cause significant short-term or long-term declines in the stock prices of relevant companies [9-12]. This suggests that the capital market "punishes" or "deters" polluting enterprises. However, the institutional environment in developing countries differs; for example, there are issues such as weak environmental laws and judicial systems and government corruption [13, 14]. Due to disparities in national economic development, there exist differences in the attitudes of developed and emerging economies towards corporate social and environmental responsibilities [15]. Studies on environmental incidents and capital market reactions in developing countries have produced conflicting results. For example, Giudici et al. [16] investigated environmental disasters such as chemical accidents and oil spills from 2003 to 2015. They discovered that the Chinese capital market may not respond effectively to negative environmental events, and no evidence shows that polluting industries face the most severe penalties. Wei et al. [17] investigated the impact of listed companies disclosing negative environmental information in China between 2009 and 2016. The findings suggest that the Chinese capital market lacks "green efficiency," which causes investors to overlook the long-term value impact of negative environmental events. Instead, irrational stock selling is simply a trading strategy designed to capitalize on market fluctuations. Research on other developing countries has also not found significant reactions of capital markets to environmental incidents [18].

This study selects China, the largest developing country, as the research subject for two main reasons: Firstly, after nearly thirty years of rapid economic growth, China's environmental pollution problems have become increasingly severe, making it a typical case for environmental research. Among these, soil pollution has become the most severe environmental challenge [19]. Since the exposure of the "cadmium rice" event in 2013, the Chinese government has attached great importance to soil heavy metal pollution. It has formulated and implemented pollution prevention and control action plans and laws [2]. These environmental regulatory efforts have enhanced developing countries' progress in environmental protection and provided valuable experience for the effective implementation of policies. Secondly, the "cadmium rice" event in China is representative. China and most other developing countries lack a comprehensive system for disclosing environmental information, making it challenging to find negative environmental events where relevant information is widely disseminated to stakeholders, affecting judgments about the effectiveness of capital markets [7]. To avoid this issue, this study focuses on a widely reported negative environmental incident that occurred in China and is well-known in society. Furthermore, existing research on developing countries often selects event samples that are either specific pollution incidents of a particular enterprise or a collection of multiple incidents within a specific period [20, 21]. Events involving a single enterprise reflect the environmentally unfriendly behavior of particular companies rather than a widespread phenomenon, limiting the possibility for the government to formulate and adjust future environmental policies. As a negative event closely associated with residents' living environment and food safety, affecting numerous enterprises across the entire industry, the great public attention to the "cadmium rice" event has brought significant social pressure. This is more likely to compel the government to implement various environmental regulations to control pollution.

The study selects the "cadmium rice" event as a natural experiment to examine the economic impact of environmental pollution events and subsequent environmental policies by investigating the stock returns of listed companies in the heavy metal industry. The research findings indicate that investors still anticipate policy adjustments in severely adverse environmental events like "cadmium rice," even in relatively weak institutional backgrounds. This anticipation suggests that potentially stricter regulatory or punitive measures will

increase the expected compliance costs for companies, thereby eliciting negative reactions in the capital markets. Investors react negatively to environmental regulation, but only significantly so in legislation or regulative policy explicitly mentioning sanctions against companies. Regarding the influencing factors of heterogeneity, a history of good company environmental performance may alleviate negative market reactions. Companies with higher social media attention also experience weaker negative reactions. Conversely, more vigorous environmental regulation in the region where the company operates will enhance negative reactions.

The marginal contribution of this article can be summarized in three ways. First, considering that the capital market is not only an important channel for enterprises to raise funds [22] but also a supplementary mechanism for government environmental regulation systems [12], This study fills a research gap in examining the effectiveness of capital markets in developing countries, distinguishing itself from previous literature that focused solely on the impact of environmental incidents or environmental regulations at the corporate level. Using the "cadmium rice" event as a natural experiment, this study assesses the capital market reaction to an environmental pollution event that affects the entire industry. Second, previous studies have focused solely on the capital market's response to a specific type of environmental regulation. Yet, different types of government environmental regulations may result in varying capital market reactions. For instance, stringent enforcement of laws may impact businesses more than other regulatory measures [6]. A robust formal environmental regulatory system serves as the foundation for capital markets to fulfill informal environmental regulatory functions [23]. Due to anticipated policy changes, environmental pollution events have a "deterrent" effect on all industry companies. This study further incorporates the different government policy regulations after the "cadmium rice" event into the analytical framework from the capital market perspective. Third, beginning with internal and external institutional and social factors, this study comprehensively examines the factors influencing the magnitude of capital market reactions. It concludes that the effective implementation of environmental regulation necessitates collaboration and mutual supervision among businesses, governments, the media, and the capital market. These insights can be used to optimize future environmental management.

Theoretical Analysis and Research Hypotheses

The primary channel through which environmental pollution incidents influence capital market reactions is the expectations of investors for future policy adjustments. Following significant environmental pollution incidents, increased attention from various sectors of society to the environmental issue will prompt the government to implement pollution control policies [24]. For example, limiting pollutant emissions, removing outdated manufacturing facilities, and penalizing non-compliant businesses. At this point, investors who purchase stocks in related companies form expectations, which are reflected in the capital market. Generally, environmental regulation has both positive and negative economic impacts. On the one hand, regulations require companies to devote some of their profits or resources to non-productive activities such as pollution control, waste management, environmental litigation, etc. [25]. As a result, investors may perceive that policy regulations reduce the company's profitability [26]. On the other hand, as the "Porter Hypothesis" suggests, strict environmental policies can encourage companies to engage in technological innovation activities, boosting competitiveness [27]. As a result, some investors might believe that policy regulations can generate value for companies [28]. When faced with stricter environmental regulations or increased corporate environmental responsibilities, investors in emerging markets are more likely to sell all or a portion of their stakes in relevant companies, resulting in negative capital market reactions [29-31]. Based on this, Hypothesis 1 is proposed:

Hypothesis 1: After the "cadmium rice" event and the announcement of related environmental regulations, listed companies in the heavy metal industry experienced significant negative abnormal stock returns.

Several factors influence how the capital market responds to environmental pollution incidents and policy regulations. Rational investors view the company's environmental performance as an important internal factor in their investment decisions [32]. When a company's environmental management fails, its brand's public image, reputation, and economic activities deteriorate, reducing investor confidence [22]. Companies with good environmental performance, on the other hand, frequently demonstrate a strong sense of environmental responsibility, significant growth potential, and ample funds. Such reputational effects may lead investors to believe these companies are relatively "clean" and less vulnerable to external environmental policy changes [33].

Institutionally, the effectiveness of a national-level environmental policy depends on the combined efforts of both the central and local governments [17]. Currently, enforcement of relevant environmental laws and regulations varies by region in China [34]. Some local governments may not provide adequate enforcement and may relax rules for certain companies that contribute to regional economic growth but lack environmental responsibility [35]. As a result, when new national-level regulatory policies are implemented and a company is located in a region with stricter environmental regulations, investors are likely to believe that the region will inevitably implement stricter regulatory measures to ensure compliance with the new policy requirements. As a result, companies may have to incur additional costs.

From a societal perspective, social media has emerged as a significant external monitoring force in the capital market [36]. When companies violate environmental rules, such as exceeding emission standards, media exposure increases the likelihood of government intervention, prompting companies to correct their actions [37]. Additionally, negative media coverage draws more public attention, imposing external constraints on companies by affecting their image and reputation [36]. The essence of media and administrative supervision is the same: both raise the cost of noncompliance for companies, reducing the likelihood of environmental violations [38]. As a result, in a more lenient environmental regulatory system, investors tend to believe that companies with greater media attention are subject to stronger environmental regulation and engage in cleaner production activities. When regulations tighten, investors believe that companies with more media attention will be less affected by policy changes. Based on this, hypotheses 2-4 are proposed:

Hypothesis 2: After the "cadmium rice" event and the announcement of related environmental regulations, the better the environmental performance of listed companies, the weaker the negative reaction observed in the capital market.

Hypothesis 3: After the "cadmium rice" event and the announcement of related environmental regulations, the stronger the environmental regulatory measures in the regions where listed companies operate, the stronger the negative reaction observed in the capital market.

Hypothesis 4: After the "cadmium rice" event and the announcement of related environmental regulation, the higher the media attention on listed companies, the weaker the negative reaction observed in the capital market.

Methodology

Selection of Event Samples

This article selects the "cadmium rice" event in 2013 as a sample of environmental incident events and important policy announcements following the event as samples of policy regulations for analysis. The policy information is sourced from the official website of the Ministry of Ecology and Environment of China (https://english.mee.gov.cn/) and the China Daily (https://www.chinadaily.com.cn/china/environment). Specifically:

Event 1: On February 27, 2013, the Southern Metropolis Daily reported news titled "Hunan Problematic Rice Flowing to Guangdong Tables," disclosing a large amount of rice with high cadmium levels entering the market, subsequently triggering public panic about food safety.

Event 2: On May 16, 2013, the Guangzhou Food and Drug Administration website released food inspection results, showing that only 44.4% of rice products on the market met the cadmium content standards. As the leading cause of excessive cadmium in agricultural products is soil contamination from industrial wastewater discharge, public attention has gradually shifted from regional food quality to nationwide industrial environmental pollution.

Event 3: On September 2, 2014, the Inter-ministerial Joint Meeting on Heavy Metal Pollution Prevention and Control was held in Beijing, emphasizing the continuous strengthening of prevention and control of heavy metal pollution and increasing punishment for enterprises violating laws and regulations.

Event 4: On May 31, 2016, the State Council issued the Action Plan for Soil Pollution Prevention and Control, emphasizing the prevention and control of heavy metal pollution.

Event 5: On February 4, 2018, the National Environmental Protection Work Conference was held in Beijing, emphasizing the comprehensive promotion of soil pollution prevention and control and the investigation of industrial enterprises related to heavy metal pollution.

Event 6: On April 16, 2018, the Ministry of Ecology and Environment issued the Opinions on Strengthening Pollution Prevention and Control in Heavy Metal-related Industries, proposing a goal of reducing the emissions of primary heavy metal pollutants in related industries nationwide by 10% by 2020.

Event 7: On August 31, 2018, China's first Soil Pollution Prevention and Control Law was published, using legal means to drive the transformation and upgrading of industries causing heavy metal pollution.

Variable Measurement

Capital Market Reaction

This article employs the event study method to calculate the cumulative abnormal returns (CAR) of sample companies in response to the "cadmium rice" event and policy regulations as a measure of the capital market reaction. This method is based on the Efficient Market Hypothesis, which holds that all information about an event is reflected in short-term stock returns in an efficient capital market [39]. The specific steps are as follows:

(1) Selection of event date and event window: The dates of events are expressed by $t = 0$. Considering market expectations due to information leakage [17], this study selects three and five trading days before and after the event date ($t \in [-3,3]$ and ($t \in [-5,5]$) as the event windows.

(2) The estimation window for this study is defined as the 190 to 11 trading days before the event ($t \in [-191, -11]$).

(3) Calculation of abnormal stock returns: To obtain more robust results, this study uses the three-factor model proposed by Fama and French [40]

and the five-factor model proposed by Fama and French [41]. The calculations for the three-factor model are as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} + s_i SBM_t + h_i HML_t + \varepsilon_{it} \quad (1)$$

Where R_{it} and R_{mt} are the stock returns of company i and market m, adjusted for risk-free returns on the t-th day. SBM_t represents the risk premium generated by company sizes, HML_t represents the risk premium generated by companies' book-to-market ratios, and ε_{it} is the regression residual. Furthermore, the abnormal return (AR) for stock i on day t is calculated as follows:

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt} + s_i SBM_t + h_i HML_t) \quad (2)$$

The calculation using the five-factor model is as follows:

$$R_{it} = \alpha_i + \beta_i R_{mt} + s_i SBM_t + h_i HML_t + r_i RMW_t + c_i CMA_t + \varepsilon_{it} \quad (3)$$

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt} + s_i SBM_t + h_i HML_t + r_i RMW_t + c_i CMA_t) \quad (4)$$

RMW_t represents the difference between the stock returns of portfolios with high and low profitability on day t, and CMA_t represents the difference between the stock returns of portfolios with high and low investment scales on day t, respectively. For detailed calculation procedures, see Fama and French [40] and Fama and French [41].

Company Environmental Performance

Enterprises typically increase their environmental investments to maintain good environmental performance [42, 43]. This study assesses environmental performance by determining whether companies made capital investments in environmental protection the year before the event occurred. This indicator is derived from the "Construction in Progress" section of each company's annual report. These costs primarily cover the treatment of solid waste, wastewater, and heavy metal emissions, energy conservation, emission reduction technology upgrades, and clean production efforts.

Environmental Regulatory Intensity

This study takes the approach of Chen et al. [44], using the number of environmental policies in each region to assess the stringency of environmental regulations in the area where the company is located. More regional policies imply that local governments exercise stricter oversight over relevant pollution. The study uses the keywords "heavy metal" and performs a full-text search on the regional regulations and rules retrieval system from PKULAW[1]. After removing irrelevant policy documents, the selected policies primarily consist of regulations, rules, normative documents, announcements, and notices relating to heavy metal pollution prevention and control.

Media Attention

News coverage frequency is a widely used measure of media attention by scholars [45]. This study uses the logarithm of the number of news reports to measure media attention to companies. Considering the increasing influence of online media [36], this study utilizes the Baidu News search engine[2]. Using the stock names of listed companies as keywords, the number of news reports on each company in the year before the event is counted through the search of titles.

Regression Model

To investigate the impact of various factors on the capital market response, this study performs the following multiple regression analysis:

$$Car^{TF}{}_{it} \text{ or } Car^{FF}{}_{it} = \alpha_0 + \alpha_1 MainVar_{it} + \alpha_2 Controls_{it} + \sum Province + \sum Year + \sum Industry + \varepsilon_{it} \quad (5)$$

Where i denotes the listed enterprise, t denotes the date. $Car^{TF}{}_{it}$ 和 $Car^{FF}{}_{it}$ are cumulative abnormal returns of the enterprise during the window period based on the three-factor model and five-factor model, respectively; $MainVar_{it}$ are the main independent variables in this study, including enterprise environmental performance ($Perf_{it}$), regional environmental regulation ($Regu_{it}$) and social media attention ($Media_{it}$). $Controls_{it}$ denoted control variables, including enterprise market value (Mv_{it}), enterprise book-to-market ratio (Bm_{it}), enterprise debt-to-asset ratio (Lev_{it}), enterprise return on assets (Roa_{it}), enterprise age (Age_{it}), state of enterprise (SEO_{it}), enterprise ownership concentration ($Top10_{it}$), industry Herfindahl Index ($Herf_{it}$), the per capita GDP of the city ($PGDP_{it}$), the proportion of industrial output value of the city ($Industry_{it}$) and the proportion of foreign investment in the city (FDI_{it}). Considering that regions with more severe pollution may have stricter environmental regulations, this study further controls for the fixed effects of the province where the enterprise is located ($\Sigma Province$). Additionally, this study further controls for fixed effects of the year ($\Sigma Year$) and the industry

[1] The website provides a policy search function covering national constitutions, laws, administrative regulations, local regulations, and departmental rules (https://pkulaw.com/).

[2] Baidu News (https://news.baidu.com/) covers over 500 news media sources nationwide, all of which are from formal sources.

Table 1. Explanation of Main Regression Variables.

Variables	Variable Description
Dependent variable	
Car^{TF}	Cumulative abnormal returns during the window period based on the three-factor model
Car^{FF}	Cumulative abnormal returns during the window period based on the five-factor model
Independent variable	
Perf	Enterprise environmental performance: a dummy variable indicating whether the enterprise incurred environmental capital expenditures in the past year. If incurred, it takes the value 1; otherwise, it takes the value 0
$Regu_{pro}$	Provincial environmental regulation: The number of heavy metal pollution regulatory policies in the province where the enterprise is located in the year before the event
$Regu_{city}$	Prefecture environmental regulation: The number of heavy metal pollution regulatory policies in the province where the enterprise is located in the year before the event[3]
Media	Media Attention: Logarithm of the number of Baidu News reports on the enterprise in the past year
Control variables	
Mv	Logarithm of the enterprise market value
Bm	Book-to-market ratio: logarithm of (book value/market value)
Lev	Debt-to-asset ratio: total liabilities/total assets
Roa	Return on assets (ROA): net profit/total assets
Age	Years since the establishment of the enterprise
SOE	Enterprise ownership: dummy variable, taking 1 for state-owned enterprises and 0 for others
*Top*10	Shareholding concentration: the sum of the shareholding proportions held by the top 10 shareholders
Herf	Herfindahl Index: the sum of the squares of the market shares (sales/total industry sales) of the top 5 enterprises in the industry.
PGDP	GDP per capita of prefecture-level cities (RMB 10,000)
Industry	Industrial output of prefecture-level cities/GDP
FDI	Amount of foreign investment in prefecture-level cities/GDP

($\Sigma Industry$). ε_{it} is the residual term. This study also conducts winsorization on all continuous variables at the 1st and 99th percentiles. The main variable definitions are shown in Table 1.

Data Source

The sample of enterprises in this study is drawn from A-share-listed companies in the Chinese heavy metal industry between 2013 and 2018. The heavy metal industry is divided into four sectors: nonferrous metal ore mining and dressing, leather/fur/feather and its products and footwear manufacturing, chemical raw materials and product manufacturing, and nonferrous metal smelting and rolling processing. After excluding ST or PT samples, samples with missing important variables, and samples where significant announcements such as quarterly or annual reports, major asset restructuring, issuance of new shares, or significant changes in main management personnel fall within the event window, a panel dataset of 613 observations is obtained. All enterprise data is derived from the CSMAR database.

Table 2 presents descriptive statistics of the main regression variables. On average, the cumulative abnormal returns of stocks of heavy metal industry-listed companies during the event window range from -0.9% to -2.2%. This average is consistent with the theoretical expectations of this study, indicating that, overall, the "cadmium rice" event and related regulatory policies have led to a negative market reaction driven by the "deterrence effect". Additionally, 42% of heavy metal-related companies in the entire sample had environmental investment expenditures in the year before event occurrence.

Results and Discussion

The Capital Market's Response to Environmental Incidents

Table 3 reports the results of t-tests and Wilcoxon signed-rank tests for the cumulative abnormal returns

[3] Measured by the sum of the number of provincial-level policies and the number of prefecture-level policies.

Table 2. Descriptive Statistics of Regression Variables.

Variables	Observations	Mean	S.d.	Min	Max
$Car^{TF}_{[-3,3]}$	613	-0.009	0.063	-0.372	0.465
$Car^{FF}_{[-3,3]}$	613	-0.013	0.064	-0.373	0.460
$Car^{TF}_{[-5,5]}$	613	-0.017	0.075	-0.405	0.424
$Car^{FF}_{[-5,5]}$	613	-0.022	0.079	-0.495	0.431
Perf	613	0.420	0.494	0	1
$Regu_{pro}$	613	3.381	4.101	0	21
$Regu_{city}$	613	4.024	4.531	0	26
Media	613	3.307	1.062	0	5.529
Mv	613	15.61	1.003	13.29	18.62
Bm	613	1.217	1.298	0.108	13.36
Lev	613	0.481	0.211	0.053	1.149
Roa	613	0.019	0.048	-0.263	0.517
Age	613	16.22	4.908	2	30
SOE	613	0.608	0.489	0	1
*Top*10	613	0.553	0.160	0.145	1
Herf	613	0.201	0.005	0.200	0.251
PGDP	613	2.534	3.009	0	47.02
Industry	613	0.413	0.140	0.043	0.695
FDI	613	0.017	0.020	0.001	0.112

of stocks of heavy metal-related companies during the "cadmium rice" event window. The capital market negatively responded to the "cadmium rice" event. Based on the results from the entire sample, heavy metal-related companies exhibit an average cumulative abnormal stock return ($Car^{FF}_{[-3,3]}$ and $Car^{FF}_{[-5,5]}$) of -2.1% in the short-term window ($t \in [-3,3]$ and $t \in [-5,5]$), which is significant at the 1% level compared to zero. This indicates that investors tend to perceive it as a negative market signal when facing nationwide environmental pollution incidents. They may anticipate increased external environmental regulatory pressures on industries associated with heavy metal pollution in the future, thereby influencing their investment decisions. I further select a long-term window $t \in [-5,30]$, and the results show that when using the five-factor model, the average cumulative abnormal stock return of heavy metal-related companies ($Car^{FF}_{[-5,30]}$) is -5.9%, which is significant at the 1% level compared to zero. As time progresses and the event unfolds, the negative reaction of the capital market is more pronounced in the long-term window compared to the short-term window. This suggests a temporal trend in the impact of environmental pollution incidents. After such an event occurs, investors require time to receive information and make assessments [46]. Table 3 also includes separate tests for subsamples based on two different events, demonstrating that the absolute value of the coefficient of negative stock cumulative abnormal returns in the Event 2 window is greater than that of Event 1. The main reason for this is that Event 2, as opposed to the initial exposure of "cadmium rice" in Event 1, has a higher number of media reports, greater intensity, and broader dissemination, resulting in a stronger reaction from the capital market. Thus, Hypothesis 1, which stated that environmental pollution incidents would cause negative reactions in the capital market, has been confirmed.

The Capital Market's Response to Environmental Regulations

Table 4 reports the results of cumulative abnormal stock return tests during the event windows of various policy releases following the "cadmium rice" event, aiming to examine the direct response of the capital market to policy regulation. The t-test results based on the entire sample show that the average cumulative abnormal stock returns within each event window do not pass the significance test. The results of the Wilcoxon

Table 3. Average Cumulative Abnormal Returns (*Car*) during the Environmental Incident Windows.

Event window	Three-factor model				Five-factor model			
	Car^{TF}	*t*	Positive: negative	*z*	Car^{FF}	*t*	Positive: negative	*z*
Total samples, including Events 1 and 2								
[-3,3]	-0.008	-1.450	59:107	-3.377***	-0.021	-3.203***	54:112	-3.163***
[-5,5]	-0.008	-1.491	48:118	-4.875***	-0.021	-3.054***	48:118	-4.632***
[-5,30]	-0.061	-5.457***	39:127	-6.192***	-0.059	-5.222***	42:124	-5.955***
Event 1 (The Southern Metropolis Daily first exposed the "cadmium rice" event)								
[-3,3]	-0.001	-0.087	30:53	-1.834**	-0.001	-0.087	27:56	-1.848*
[-5,5]	-0.012	-1.207	25:58	-2.601***	-0.014	-1.260	25:58	-2.402**
[-5,30]	-0.044	-2.793***	21:62	-3.709***	-0.048	-3.012***	25:58	-3.768***
Event 2 (The Guangdong Food and Drug Administration again exposed the "cadmium rice" event)								
[-3,3]	-0.022	-8.916***	23:60	-3.786***	-0.020	-8.313***	25:58	-3.434***
[-5,5]	-0.026	-10.886***	26:57	-3.786***	-0.023	-10.086***	25:58	-3.496***
[-5,30]	-0.078	-4.947***	18:65	-5.035***	-0.069	-4.377***	17:66	-4.649***

Note: *t* and *z* represent the statistics for t-tests and Wilcoxon signed-rank tests, respectively. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

signed-rank test are significant only in the short-term window. Based on the results from subsamples, in the short-term window ($t \in [-3,3]$ and $t \in [-5,5]$), the capital market exhibits a significant negative response to Event 7 (the release of the *Soil Pollution Prevention and Control Law*). This is because this event elevates heavy metal pollution control to the legislative level for the first time, and legislative environmental regulations generally have stronger enforceability than administrative controls [47]. Furthermore, according to the t-test results, in the short-term window ($t \in [-5,5]$), the capital market also exhibits a significant negative response to Event 6 (the release of the Opinions on Strengthening Pollution Prevention and Control in Heavy Metal-related Industries). This policy explicitly mentions strict provisions and assessment plans for heavy metal-related companies. It proposes to carry out appropriate enforcement actions, leading investors to believe this policy has a solid binding force.

Overall, the expectations for the capital market response to environmental regulation in Hypothesis 1 are not entirely validated, which appears to contradict the conclusion drawn from existing research that environmental regulation in China causes negative market reactions [6, 30]. Several factors determine how the capital market reacts to an environmental regulation policy. On the one hand, it depends on the type and content of the policy and how investors interpret it. For example, investors are more assured about the effectiveness of the legislative policy or explicit intervention measures for specific companies. The negative market reactions to Events 6 and 7 highlight this point. On the other hand, the market response is also influenced by investors' inferences based on factors such as the company's environmental performance before regulation and the strength of policy enforcement by local governments. This will be discussed further in the following section. Furthermore, while policy regulation plays an important role in the capital market response to the "cadmium rice" event, the findings of this study show that the direct reaction of the capital market to policy regulation is weaker than the incident itself. One possible explanation is that, compared to policy, environmental pollution incidents receive more sustained public attention, making investors more sensitive and attentive. Due to information asymmetry between investors and policymakers, investors may not fully understand the government's future actions based solely on policy content. If investors do not expect the policy to result in stricter environmental regulations, it may not weaken investors' trust in their stock investments.

Influencing Factors of the Capital Market Response to Environmental Incidents and Policy Regulation

Tables 5 and 6 show, using different methods and event windows, the impact of various factors on the cumulative abnormal stock returns of companies during the "cadmium rice" event and policy regulation windows. In terms of company factors, the regression coefficients of environmental performance (*Perf*) range from 0.032 to 0.044, according to the results in Table 5, columns (1)-(8). This implies that, on average, companies that invested in environmental protection before the "cadmium rice" event saw a reduction

Table 4. Average Cumulative Abnormal Returns (*Car*) during the Policy Regulation Event Windows.

Event window	Three-factor model				Five-factor model			
	Car^{TF}	*t*	Positive: negative	*z*	Car^{FF}	*t*	Positive: negative	*z*
Total sample								
[-3,3]	-0.002	-0.514	213:234	-0.940	-0.002	-0.432	190:257	-1.667*
[-5,5]	-0.005	-1.200	197:250	-1.623	-0.004	-0.863	193:254	-1.987**
[-5,30]	-0.007	-0.888	212:235	-1.030	-0.008	-0.988	210:237	-1.054
Event 3 (Convening of the Inter-ministerial Joint Meeting on Heavy Metal Pollution Prevention and Control)								
[-3,3]	0.004	0.404	30:48	-1.706*	-0.002	-0.188	28:50	-2.468**
[-5,5]	-0.000	-0.011	26:52	-2.124**	-0.008	-0.619	25:52	-2.787***
[-5,30]	-0.037	-1.758*	27:51	-2.851***	-0.050	-2.294**	24:54	-3.285**
Event 4 (The release of the Action Plan for Soil Pollution Prevention and Control)								
[-3,3]	-0.007	-1.100	29:55	-2.431**	-0.009	-1.438	25:59	-2.872***
[-5,5]	-0.006	-0.712	30:54	-1.797*	-0.008	-0.803	30:54	-1.592
[-5,30]	-0.025	-1.356	30:54	-2.163**	-0.034	-1.552	30:54	-2.350**
Event 5 (Convening of the National Environmental Protection Work Conference)								
[-3,3]	0.007	0.702	60:36	1.988	-0.006	-0.457	62:34	3.369***
[-5,5]	0.005	0.476	57:39	1.750*	0.004	0.294	65:31	3.621***
[-5,30]	0.019	1.047	61:35	2.511*	0.031	1.602	64:32	2.953***
Event 6 (The release of Opinions on Strengthening Pollution Prevention and Control in Heavy Metal-related Industries)								
[-3,3]	-0.001	-0.086	54:39	1.297	-0.008	-1.118	44:49	-0.412
[-5,5]	-0.009	-1.948*	48:45	-0.339	-0.019	-2.329**	42:51	-1.933**
[-5,30]	0.009	0.741	50:43	0.791	0.033	2.550**	59:34	2.902
Event 7 (The release of Soil Pollution Prevention and Control Law)								
[-3,3]	-0.010	-1.725*	40:56	-2.017*	-0.017	-2.683***	30:66	-3.475***
[-5,5]	-0.015	-2.209**	36:60	-2.258**	-0.023	-3.281***	31:65	-3.877***
[-5,30]	-0.006	-0.498	44:52	-0.537	-0.030	-2.258**	33:63	-2.657***

Note: *t* and *z* represent the statistics for t-tests and Wilcoxon signed-rank tests, respectively. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

in negative impact ranging from 3.2% to 4.4%, confirming Hypothesis 2. Because of the expectation of corresponding policy adjustments resulting from environmental pollution incidents, companies with good environmental performance face less pressure, gaining greater recognition from the capital market regarding environmental protection. Similarly, the findings in Table 6 show that companies with better environmental performance will experience fewer negative consequences when new environmental policies are implemented.

From an institutional standpoint, the regressions in Table 5 show that the coefficients of provincial environmental regulation intensity ($Regu_{pro}$) are significantly negative in the short-term windows ($t \in [-3,3]$ and $t \in [-5,5]$), while the coefficients of prefecture environmental regulation intensity ($Regu_{city}$) are negative but only statistically significant in the window $t \in [-5,5]$. Table 6 shows that provincial and prefectural environmental regulation coefficients are significantly negative at the 5% or 10% levels. These results generally suggest that companies in areas with more vigorous environmental enforcement are more likely to face stricter government regulation. As a result, the enterprises have higher costs to meet the new policy standards and face more negative consequences, supporting Hypothesis 3.

From a social standpoint, Table 5 shows that the coefficient of media attention (*Media*) on the capital market response to the "cadmium rice" event is not significant, implying that the expectation of Hypothesis 4 is unfounded in this case. However, the results

Table 5. Regression Analysis of Factors Influencing the Capital Market Response to Environmental Incidents.

	$Car^{TF}_{[-3,3]}$		$Car^{FF}_{[-3,3]}$		$Car^{TF}_{[-5,5]}$		$Car^{FF}_{[-5,5]}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Porf	0.033**	0.032**	0.034**	0.033**	0.042**	0.041**	0.044**	0.042**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.011)	(0.010)
$Regu_{pro}$	-0.002**		-0.003*		-0.002*		-0.003*	
	(0.001)		(0.001)		(0.001)		(0.001)	
$Regu_{city}$		-0.004		-0.005		-0.010*		-0.010*
		(0.005)		(0.005)		(0.003)		(0.003)
Media	-0.003	-0.003	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.003)
Mv	0.017	0.017	0.017	0.017	0.015	0.015	0.013	0.014
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.008)	(0.010)	(0.009)
Bm	-0.014	-0.016	-0.010	-0.012	-0.003	-0.005	0.004	0.001
	(0.024)	(0.022)	(0.025)	(0.023)	(0.014)	(0.013)	(0.017)	(0.016)
Lev	-0.032	-0.028	0.004	0.009	0.042	0.047	0.076**	0.082**
	(0.064)	(0.067)	(0.085)	(0.088)	(0.032)	(0.028)	(0.023)	(0.018)
Roa	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Age	-0.013*	-0.013*	-0.013*	-0.013	-0.012	-0.012	-0.011	-0.011
	(0.004)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)
SOE	0.009	0.010	-0.003	-0.003	-0.024	-0.024	-0.046	-0.047
	(0.047)	(0.041)	(0.067)	(0.060)	(0.059)	(0.053)	(0.082)	(0.074)
*Top*10	167.199	169.580	286.627*	289.538*	491.345*	493.808**	623.008**	626.253**
	(182.707)	(179.836)	(108.069)	(104.189)	(158.064)	(154.860)	(145.763)	(143.087)
Herf	0.009***	0.009**	0.010***	0.010**	0.005*	0.005*	0.006*	0.006*
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
PGDP	0.147	0.157*	0.152	0.163*	0.285**	0.294**	0.308**	0.318**
	(0.067)	(0.062)	(0.074)	(0.067)	(0.062)	(0.061)	(0.060)	(0.056)
Industry	-0.006	-0.005	-0.006	-0.005	0.000	0.001	0.000	0.001
	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.009)	(0.009)
FDI	0.033**	0.032**	0.034**	0.033**	0.042**	0.041**	0.044**	0.042**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.011)	(0.010)
Constant	-33.564	-34.040	-57.478*	-58.059*	-98.463*	-98.955**	-124.833**	-125.480**
	(36.626)	(36.052)	(21.719)	(20.942)	(31.730)	(31.085)	(29.229)	(28.687)
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	166	166	166	166	166	166	166	166
Adj R-sqr	0.279	0.281	0.294	0.298	0.318	0.321	0.330	0.334

Note: *t*-values are presented in parentheses; the standard errors of regression coefficients are robust standard errors clustered at the industry level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Regression Analysis of Factors Influencing the Capital Market Response to Policy Regulation.

	$Car^{TF}_{[-3,3]}$		$Car^{FF}_{[-3,3]}$		$Car^{TF}_{[-5,5]}$		$Car^{FF}_{[-5,5]}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Porf	0.008*	0.008*	0.007*	0.007*	0.020**	0.020**	0.018*	0.018*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
$Regu_{pro}$	-0.003*		-0.003**		-0.002*		-0.003*	
	(0.001)		(0.001)		(0.001)		(0.001)	
$Regu_{city}$		-0.003**		-0.004**		-0.003**		-0.004***
		(0.001)		(0.001)		(0.001)		(0.001)
Media	0.002	0.002*	0.003**	0.002**	0.003*	0.003**	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Constant	-10.355	-10.825	-4.414	-4.951	17.510	17.200	26.220	25.850
	(15.583)	(15.266)	(14.461)	(14.083)	(21.916)	(21.709)	(22.698)	(22.414)
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	447	447	447	447	447	447	447	447
Adj R-sqr	0.070	0.076	0.063	0.070	0.058	0.062	0.063	0.068

Notes: The selection and definition of control variables are the same as in Table 4; *t*-values are presented in parentheses; standard errors of regression coefficients are robust standard errors clustered at the industry level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

in Table 6 show that the media attention coefficient on the capital market response to policy regulation is generally positive at 1% or 10%. This suggests that media supervision leads to a hidden cost of noncompliance for businesses, discouraging them from making environmentally harmful decisions. When an environmental policy is implemented, companies that receive more media attention are more likely to be perceived favorably by investors in terms of environmental performance, leading investors to believe that the likelihood of noncompliance is lower.

Conclusions

This article uses the event study method to systematically examine the capital market response to the "cadmium rice" event and the following policy regulations. It also examines the factors that influence capital market reactions across three categories: company factors, institutional factors, and societal factors. The study findings are as follows: Firstly, the capital market responded negatively to the "cadmium rice" event, manifested by significant negative abnormal stock returns of listed companies in the heavy metal industry during the event window. Secondly, concerning governmental environmental regulations adopted following the "cadmium rice" event, listed companies in the heavy metal industry experience significant negative abnormal stock returns during event windows of legislation or regulative policy explicitly mentioning sanctions against companies while not significant in other policy events. This is related to investors' expectations regarding the implementation effectiveness of different policies. Thirdly, regarding the factors influencing the capital market's negative reactions to the "cadmium rice" event and policy regulations, companies' past environmental performance significantly mitigates negative responses to the capital market. The stronger the enforcement of environmental regulations in the region where the company is located, the more negative the reactions of the capital market. Additionally, the more media attention is paid to the company, the fewer negative reactions the capital market will have, although this conclusion only holds for policy regulation events.

This article includes the following discussions and policy suggestions: First, only when the environmental information is fully disclosed can the capital market effectively respond to environmental events. Environmental regulatory agencies need to improve the management of company environmental and social responsibility information disclosure to help stakeholders accurately know the environmental performance of enterprises, thereby enabling the capital market to play an incentive role in company environmental protection. Second, from the standpoint

of companies, environmental performance is critical when environmental incidents occur. Enterprise managers should actively fulfill social responsibilities, implement effective environmental protection, and integrate green innovation research and development into their long-term strategies to fully take advantage of the reputation effects of environmental performance and gain a competitive advantage. Third, from the government's perspective, the implementation of environmental policies differs across regions, and local governments must balance economic growth and the environment [48]. The central government should strengthen relevant assessments to ensure that new policies are strictly implemented across regions once they are introduced. Fourth, from a societal standpoint, social media is a professional medium for gathering, processing, and disseminating information. It is the primary channel through which the public can access information, thereby reducing information asymmetry between the public and businesses regarding environmental responsibilities. In the future, social media should be fully utilized to strengthen environmental information disclosure and supplement the government's external environmental governance.

Although this article only selects environmental incidents in China as the subject of analysis, the research findings are meaningful for other developing countries worldwide. Firstly, in recent years, preventing and controlling heavy metal pollution has been one of the biggest challenges many developing countries face. This environmental issue is not confined to China alone; heavy metal pollution in soil or surface water has also been detected in India [49] and Bangladesh [50]. Foods containing excessive heavy metal elements can lead to a series of severe health issues such as kidney damage, osteoporosis, and cancer, thereby compromising the welfare of residents [51]. Secondly, as governments and societies in developing countries continue to make efforts to control heavy metal pollution, capital markets promote the redistribution of resources, which can serve as a supplement to environmental management systems. Effective capital markets can respond negatively to companies engaging in polluting activities, encouraging them to adopt necessary production technology improvements to enhance environmental performance, aligning with governments' goal of environmental regulation [52]. Thirdly, the findings of this article can provide references for developing countries to explore the conditions for effectively utilizing the resource allocation function of capital markets. Despite much literature pointing out that capital markets in developing countries are often insufficiently "green" and effective [16, 17, 53, 54], one possible reason is the selection of events. Repetitive environmental incidents selected are not reported by the media and may not attract the attention of a large number of investors [55]. This study reveals that China's capital market can respond to negative environmental incidents like the "cadmium rice," which is related to food safety. Investors consider environmental issues and incorporate them into their resource allocation decisions. Another reason for the mild market response broadly concerns the weak environmental legal system and unclear environmental enforcement standards in developing countries. This leads to polluting companies facing little punishment and lacking the incentive to invest in environmental protection [56]. The informal environmental regulation in the capital market requires strong formal regulation as support [23]. This study finds that only under specific conditions can capital markets in developing countries serve as effective pollution control tools by comparing the impacts of different types of post-event environmental regulations: the full disclosure of environmental information and strict enforcement of environmental laws and regulations.

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Conflict of Interest

The author declares no conflict of interest.

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