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Does Environmental Information Disclosure Benefit Waste Discharge Reduction? Evidence from China

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Abstract As a tool for regulating the environment in China, does environmental information disclosure reduce pollutant discharge? To answer this question, we empirically analyzed the emission data of "the three wastes" (i.e., waste gas, wastewater, and solid waste) in unit industrial GDP in 31 provincial units. As a measure to reduce institutional emission, environmental information disclosure only slightly influenced waste discharge reduction in the implementation period of the Eleventh Five-Year Plan of China. Instead, command control and market-based tools significantly affected waste discharge reduction. Representative measures included penalties and charges. With the continuously enhanced pressure of control, environmental information disclosure facilitates the effects of command control tools on waste discharge reduction. Content analysis of environmental information disclosed by sample listed companies in Jiangsu Province was conducted. The disclosure of insufficient environmental information on emission reduction can be attributed to "adverse selection" in system performance (i.e., the selective disclosure trend considering "greenwashing" in the listed companies) and to the limited quality of overall environmental information disclosure. This study provides empirical evidence for Chinese policy makers to improve the system for environmental information disclosure of listed companies.

Keywords Content analysis · China · Environmental information disclosure · Environmental auditing · Institutional emission reduction · Waste discharge reduction

Introduction

China launched its economic reforms in 1978 and has since achieved remarkable progress. China is the second largest economy and largest exporter in the world. However, the rapid economic growth of the country was achieved at the expense of the ecological environment. OECD (2007) found that the amount of discharged wastewater from the unit growth of GDP in China is four times greater than that in developed countries. The amount of solid waste from unit industrial output is ten times greater than that in developed countries. Seven of the top ten polluted cities in the world are located in China. The Environmental Performance Index (of Yale University) of China ranks 116th among 132 countries and regions, even below several less developed countries (YCELP 2013). The Kuznets curve hypothesis may not be applicable to China because of the worsening environmental crisis in the country. The Kuznets curve hypothesis suggests that environmental problems are naturally resolved at a certain level of economic growth. However, China may lose its environmental carrying capacity before its economic growth develops its capacity to solve environmental problems. Therefore, Chinese policy makers should focus on finding ways to promote both economic growth and environmental protection.

In environmental regulation, tools for controlling pollution can be divided into three basic categories according to their characteristics: legal regulations ("stick"),

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economic incentives ("carrot"), and voluntary agreements ("sermons") (Bemelmans-Videc et al. 1998). The evolution of such tools undergoes three main stages. First-generation policy (command control instruments) is influenced by environmental interventionism. Legal aspects are regarded as a starting point, and instruments include market entry and exit regulations, product standards and bans, process specifications, and technical standards. Second-generation policy comprises market-based tools, which are influenced by ownership-based market environmentalism. These tools include property rights, such as emission or environmental taxes, emission trading systems, environmental subsidies, and deposit–refund systems. Third-generation policy is information-based regulation and voluntary environmental management, which are influenced by the autonomous governance of the environment. This policy underlines protocols, such as information disclosure, voluntary compliance agreements, environmental labels, and environmental management systems.

Environmental regulation in China before the 1980s was primarily achieved by command control because of the planned economic system. With the introduction of fee levying for pollution discharge in the 1980s, China integrated command control and market-based tools as strategies to control pollution. In the twenty-first century, China introduced the trading of emission permits, environmental information disclosure, and other policy tools to pollution control. In 2006, the Shenzhen Stock Exchange issued *Principles and Recommendations of Social Responsibility of Listed Companies*. Later, in May 2008, the Shanghai Stock Exchange issued a *Guide for Environmental Information Disclosure of Listed Companies*. These guides specified the forms, ranges, and procedures of the environmental information disclosure of listed companies. As an information-based tool, environmental information disclosure improves the system of environmental regulation in China and encourages people to participate in determining whether such disclosure can achieve pollutant discharge reduction. Different answers to this question have immense significance to the establishment and improvement of an environmental policy network suitable for China.

Studies of environmental regulation policies in China and their effects have primarily concentrated on administrative control and fee levying for pollution discharge (Dasgupta et al. 2001; Wang and Wheeler 2003, 2005; Wang and Jin 2007; Wu 2010). Several scholars have studied environmental information disclosure in China, but they have focused on behavior motivation, influencing factors, and market reaction to the environmental information disclosure of enterprises (Zeng et al. 2010; Kuo et al. 2012; Meng et al. 2013). Few studies have connected environmental information disclosure with the targets of pollution control.

This study has three significant contributions. First, the effect of a system of environmental information disclosure of listed companies on the target of pollutant discharge reduction in China was investigated for the first time. Findings showed that environmental information disclosure is not an ideal tool for environmental regulation in China. However, interactions between environmental information disclosure and environmental administrative punishment remarkably affect pollutant discharge reduction and thereby enrich literature on the relationship between pollution control and information disclosure in developing countries. Second, this study found that the environmental information disclosure in China inadequately reduces emissions because the transition economy has an ineffective law enforcement system (Garrod 2000). In this context, programs for information disclosure are often exploited by listed companies to advertise their social responsibility. However, few companies have reduced their environmental risks or liabilities. Finally, most studies have analyzed environmental information disclosure in China from the perspective of enterprises or industries. Our study analyzed environmental information disclosure on the basis of the panel data of listed companies at the provincial level in China. Thus, the study demonstrates its macroscopic significance and overcomes the limitations of previous findings. The findings of this research can be used to improve the mechanism of environmental information disclosure and supervision of China and can guide information-based tools for controlling pollution in other developing countries during their economic transition.

Literature Review

The selection and implementation of tools for controlling pollution are popular topics in research on environmental management. Tools for command control quickly achieve control and pollution treatment, which are unrestricted by the properties of pollution sources and spatial factors. Command control is effective in pollutant discharge reduction (Lee 1999; Dasgupta et al. 2001). However, command-based control has been tainted by obvious administrative color, producing high costs of emission reduction and contradicts the motivation of enterprises for technological innovation (Maloney and Bruce 1984; Nordberg-Bohm 1999; Joshi et al. 2001). Compared with command control regulation, market-based tools are superior because of their low cost, high efficiency, and inclination toward technological innovation and diffusion (Kolstad 1986; Bohm 1997). Therefore, market-based tools are favored by economists. However, the effects of market-based tools remain controversial. For example, several studies have observed that sewage charge is an effective policy tool (Bressers and Schuddeboom 1994; Barker and Kfhler 1998; Wang and Wheeler 2005), whereas other studies have found that the effect of sewage charge on environmental improvement to be limited because of insufficient information for imposing suitable tax rates, ineffective enforcement, and human factors (Rock 2002; Bruvoll and Larsen 2004). Developing countries face more problems in using market-based tools than industrialized countries because of institutional environment and political relationships (Blackman and Harrington 2000).

Pollution control tools are continuously innovated under the complexity of environmental issues (World Bank 1998). Information disclosure is one of "the third generation" of tools for controlling pollution (Tietenberg 1998). Information disclosure reduces information asymmetry and thus affects the attitudes of information users or stakeholders toward willingly or unwillingly establishing, maintaining, or improving a certain relationship with information providers. Therefore, information disclosure affects organizational performance (Khanna 2001). The extensive application of information disclosure as a tool for environmental regulation can be interpreted by changes in cost and time efficiency in providing, processing, and disseminating related information (Lundqvist 2001; Jordan et al. 2003). Environmental information disclosure is of two types (Dasgupta et al. 2007). One practice only regularly discloses data on pollutant emissions, such as the Toxic Release Inventory (TRI) in the United States and the environmental information disclosure of listed companies in China. The other practice not only regularly discloses data on pollutant emissions but also evaluates performance, such as the Performance Evaluation and Ratings Program (PERP) in Indonesia, the Green Rating Project (GRP) in India, the EcoWatch Program in the Philippines, and the Green Watch Program (GWP) in China.

The United States is one of the earliest countries to disclose information on toxic pollutants. Since the implementation of TRI in 1986, air and water emissions have been significantly reduced (Konar and Cohen 1997; Bennear and Olmstead 2008; Montes-Sancho and Delmas 2010). García et al. (2007, 2009) analyzed the effects of PERP in Indonesia and found that PERP has significantly reduced pollutant emissions. Foreign-invested enterprises, enterprises in densely populated areas, and enterprises with low environment ratings are sensitive to PERP. Dasgupta et al. (2004) analyzed and compared the effects of GWP in two Chinese cities of different levels of economic development, namely, Zhenjiang and Hohhot. GWP labels corporate environmental performance with different colors, namely, green, blue, yellow, red, and black (from good to bad) and discloses these labels to the public. Follow-up surveys showed that environmental information disclosure positively affects emission reduction among enterprises. Powers et al. (2011) empirically analyzed the pulp and paper making industry in India and found that dirty plants with poor environmental protection significantly reduce their emissions through GRP, whereas clean plants only slightly reduce their emissions. In addition, GRP more significantly affects affluent areas than poor areas.

However, several researchers question the effects of information disclosure on pollutant discharge reduction as an environmental policy. Foulon et al. (2002) found that compared with traditional tools for command control, information disclosure fails to provide sufficient incentives for controlling pollution in British Columbia, Canada. Koehler and Spengler (2007) analyzed the aluminum industry in America and highlighted that TRI significantly reduces pollutant emissions. However, the reduction was the product of integrated policy tools, including market regulation and legal controls, rather than of TRI solely. On the basis of the dynamic game model, Uchida (2007) asserted that eco-labeling and comprehensive information disclosure do not necessarily achieve pollutant discharge reduction. Comprehensive information disclosure is most effective with minimal environmental contamination or low minimum emission standards. Brouhle et al. (2009) evaluated two policy levers of the pollutant discharge of the metal-finishing industry in the United States. Empirical analysis revealed that the policy tool of voluntary information disclosure only slightly affects emission reduction. Meanwhile, the traditional policy tool of administrative supervision passed the test of significance. Koehler (2008) used an advanced approach to assess voluntary environmental programs (VEPs). VEPs produce no ideal effects, contradicting traditional analysis. Koehler also discussed diversified explanations, including institutional constraints and participant motivation. Kathuria (2009) found that among developing and transitioning countries, the effectiveness of environmental information disclosure depends on an accountable and credible plan that enables the inspection of information quality at key points. Blackman (2010) comprehensively analyzed successful and unsuccessful PERP cases and highlighted that PERP in developing countries is effective only under certain conditions. Therefore, whether PERP is a promising policy tool in developing countries requires further research.

Institutional Background and Hypothesis Development

We hypothesized and analyzed whether China has appropriate conditions for effective environmental information disclosure in the following aspects.

China has rapidly grown for over 30 years since its economic reform and opening-up, a phenomenon regarded as "an economic miracle." Traditional economic theories hold that China is unqualified to produce the "miracle" in terms of per capita resource endowments and technological innovation. Several scholars have explained the economic growth of China in terms of politics and economics and have argued that China uses unique approaches to provide strong incentives for local governments (Montinola et al. 1995; Jin et al. 2005; Li and Zhou 2005).

In China, the political advancement of local government officials and determined local fiscal revenues have long been directly influenced by regional GDP growth. Because of such incentives, local governments have significantly influenced the economic miracle in China. When a superior government proposes an indicator of economic development, subordinate governments compete to create more ambitious development indicators. The passion of these governments for finding all possible resources for investment and boosting local economic development is rare in the world.

This tournament mode of economic development influences the implementation of environmental policies. Listed companies in each province obtain a certain asset size and revenue, which are regarded as crucial local tax resources and main drivers of GDP growth. The intention of local governments to control pollution is often compromised because of the pressure of economic growth. To maintain the competitiveness of key enterprises, local governments use strategies in implementing superior policies, such as the central government policy on environmental information disclosure. Specifically, local governments allow listed companies to deal with information disclosure as they wish.

Hettige and Wheeler (1996) studied pollution control in South and Southeast Asian countries and found several clean plants although formal regulatory pressure is remarkably weak. They attributed this finding to informal regulatory pressures. Informal pressure reduces the discharge capacity of enterprises and primarily includes resistance to and complaints of environmental pollution from environmental NGOs, consumers, and the public.

Compared with environmental NGOs in developed countries, those in China started late and are faced with difficulties such as limited size and deficient funds, devices, and techniques. For example, the first environmental NGO in China, Friends of Nature, has over 10,000 members and an annual membership fee of less than 100,000 dollars. Such limited resources enable this NGO to manage only several environmental education activities symbolically instead of engaging in large-scale environmental protection. Ricky and Lorett (2000) found that ecological impact is positively correlated with ecological knowledge and the willingness of consumers to buy green products. However, ecological knowledge and purchasing behavior in China are lagging. Green consumption in China still needs a long period to be widely accepted. In China, the public are increasingly concerned about environmental issues, but society lacks feasible legal and institutional frameworks. No actual public participation in environmental protection has been observed in China (Li et al. 2012). Complaints and petitions of the public are often confined to pollution issues, which are often easily identified and have low risks. For lethal and hardly identifiable toxic pollutants, complaints from the public are ineffective or are rarely noticed.

Despite the growing environmental awareness in all sectors of Chinese society, the information disclosure regarding corporate environmental information is limited. The influence of public opinion, local government, environmental NGOs, and their own consumers has not greatly changed corporate environmental practices. Disclosure has become merely a form of advertising for certain companies to put forward an environmentally friendly facade toward the general public. These pseudo-environmentally conscious companies are less likely to implement actual pollution controls, the failure of which hardly improves the environment. Therefore, we propose the following hypothesis:

Hypothesis 1 Environmental information disclosure has little effect of reducing the emission of major pollutants in China.

In environmental information disclosure, key attention shall be paid to what is not disclosed rather than what is disclosed. Stakeholders may fail to effectively regulate the quality of environmental information disclosure as regulatory and non-regulatory pressures continue to be very weak in China. The lack of third party corroboration among the listed companies contributes to this lack of pressure. The current practice of environmental disclosure becomes "greenwashing" (Lyon and Maxwell 2011), with certain executives taking selective tactics in their methods of environmental disclosure. Therefore, we propose the following hypothesis:

Hypothesis 2 In China, the listed companies use environmental information disclosure to promote a more positive environmental image than a negative one.

Overall Effects of Waste Discharge Reduction in China from 2006 to 2010

To facilitate our study, the overall effects of pollutant discharge reduction during the Eleventh Five-Year Plan period in China were investigated.

The Five-Year Plan, which began in the 1950s, refers to the national economic and social development plans of the

Table 1 Emission reduction effects of "three wastes" and main pollutants in unit industrial GDP during Eleventh Five-Year Plan period in China

Indicator	2005	2006	2007	2008	2009	2010	Total emission reduction rate	Average annual emission reduction rate	Obligatory target
Industrial wastewater	31.48	27.55	24.62	21.95	19.59	17.68	43.84	10.89	–
Chemical oxygen demand	183.11	163.83	137.95	119.94	106.70	92.15	49.68	12.81	8
Ammonia	19.40	16.22	13.21	11.53	10.24	8.95	53.87	14.29	10
Industrial waste gas	3.48	3.80	3.88	3.67	3.64	3.86	−10.92	−2.22	–
Sulfur dioxide	330.10	296.97	246.39	210.79	184.95	162.64	50.73	13.17	8
Fume	153.11	124.90	98.49	81.88	70.80	61.71	59.70	16.56	–
Industrial dust	117.98	92.73	69.75	53.12	43.73	33.40	71.69	22.27	–
Industrial solid wastes	214.25	149.37	119.47	71.00	59.34	37.08	82.69	28.96	–

Industrial waste water is given ten thousand tons per one hundred million RMB, industrial waste gas is given one hundred million standard cube per one hundred million RMB, industrial solid wastes and others pollutants are given tons per hundred million RMB. All ratios are shown as percentages. The material originates from calendar year *China Environment Yearbook* and *China Statistical Yearbook*

Chinese government. The First Five-Year Plan was implemented from 1953 to 1957. The Second Five-Year Plan started in 1958, and so on. The Third Five-Year Plan should have started in 1963, but because of the Great Leap Forward movement in the initial period of the establishment of the country, the plan resulted in the major disproportion of the national economy and thus required adjustment and left a 3-year blank period. Therefore, the Third Five-Year Plan started in 1966. The Eleventh Five-Year Plan was from 2006 to 2010. During that period, the average annual GDP growth of China exceeded 8 %. Since 2006, environmental information disclosure has gradually institutionalized among listed companies in China.

Table 1 shows the emission reduction effects of "three industrial wastes" (waste gas, wastewater, and solid waste) and main pollutants based on national data. Compared with that at the end of the Tenth Five-Year Plan, the emission reduction of solid waste in the "three industrial wastes" is the most effective, and overall emission is reduced by 82.69 %. However, the emission reduction of waste gas fails. Waste gas emission in unit industrial GDP in 2010 was 10.92 % higher than that in 2005.

The emission of sulfur dioxide, fume, industrial dust, chemical oxygen demand, ammonia, and other main pollutants in unit industrial GDP was significantly reduced. The average annual emission reduction rate varied from 12.81 to 28.96 %. The emission of industrial dust had the maximum decline (71.69 %). The minimal emission reduction of chemical oxygen demand reached 49.68 %. The average annual emission reduction indicator of chemical oxygen demand, sulfur dioxide, and ammonia achieved the obligatory emission reduction targets of the National Environment Protection Bureau in China.

The emission reduction effects of the "three wastes" in 31 Chinese provinces are shown in Table 2. The environmental performance of various provinces showed remarkable differences. Although the emission of the "three wastes" was reduced significantly in some provinces, the emission intensity of the "three wastes" in some other provinces was ineffectively controlled. During the Eleventh Five-Year Plan period, wastewater emission in unit industrial GDP was reduced to different levels all over the country. Emission reduction ranged from 77.88 to 11.18 %. The best performance in the emission reduction of waste gas in unit industrial GDP was contributed by Tibet, reaching 42.47 %. The worst emission reduction was observed in Ningxia, where emission increased by 176.93 %. Jiangxi recorded the maximum emission reduction of solid waste in unit industrial GDP (39.01 %). The worst emission reduction of solid waste was in Xinjiang, where emission increased by 73.27 %.

Based on the above analysis, although different provinces produced different emission reduction effects during the Eleventh Five-Year Plan period, the overall emission level of pollutants in unit industrial GDP was reduced annually. Our concern is to determine whether the environmental information disclosure system influenced the outcome and how insensitive the influence was.

Research Design

Existing data or information on the environmental information disclosure of listed companies in China is unavailable. Therefore, through manual collection, we obtained the listed companies of industry and public service as objects of study, thereby aligning with the statistical caliber of pollutant discharge. All data were collected from annual reports of listed companies in A stock markets from 2007 to 2011. Final data were calculated based on data

Table 2 Emission of "three wastes" in unit industrial GDP in different provinces during Eleventh Five-Year Plan period in China

Region	2005			2010			Emission reduction rate		
	Waste water	Waste gas	Solid waste	Waste water	Waste gas	Solid waste	Waste water	Waste gas	Solid waste
Beijing	7.506	2.069	0.725	3.000	1.738	0.464	60.03	16.00	36.00
Tianjin	15.958	2.441	0.596	4.542	1.774	0.430	71.54	27.32	27.85
Hebei	26.694	5.684	3.490	13.465	6.639	3.735	49.56	−16.80	−7.05
Nshanxi	15.158	7.150	5.281	13.463	9.498	4.931	11.18	−32.84	6.63
Neimeng	16.894	8.168	4.982	9.808	6.819	4.216	41.94	16.52	15.38
Liaoning	30.110	5.990	2.935	9.258	3.489	2.236	69.25	41.75	23.82
Jilin	30.199	3.621	1.801	12.258	2.613	1.472	59.41	27.84	18.27
Heilongjang	16.748	1.951	1.191	7.864	2.043	1.092	53.05	−4.72	8.31
Shanghai	12.374	2.054	0.476	5.426	1.918	0.362	56.15	6.62	23.95
Jiangsu	31.744	2.164	0.617	14.681	1.737	0.505	53.75	19.73	18.15
Zhejiang	30.307	2.051	0.396	19.752	1.856	0.388	34.82	9.51	2.02
Anhui	34.913	3.827	2.308	16.967	4.267	2.189	51.40	−11.50	5.11
Fujian	46.066	2.204	1.327	20.317	2.210	1.225	55.90	−0.27	7.69
Jiangxi	37.081	3.009	4.814	22.632	3.062	2.936	38.97	−1.76	39.01
Shandong	14.534	2.522	0.959	11.182	2.354	0.861	23.06	6.66	10.22
Henan	25.220	3.165	1.262	14.906	2.251	1.062	40.90	28.88	15.85
Hubei	37.936	3.860	1.515	17.778	2.606	1.280	53.14	32.49	15.51
Hunan	55.911	2.746	1.537	19.323	2.966	1.167	65.44	−8.01	24.07
Guangdong	22.092	1.283	0.276	9.350	1.204	0.273	57.68	6.16	1.09
Guangxi	115.121	6.593	2.759	54.478	4.788	2.055	52.68	27.38	25.49
Hainan	47.567	5.827	0.813	17.107	4.024	0.627	64.04	30.94	22.88
Chongqing	82.948	3.572	1.737	18.345	4.443	1.152	77.88	−24.38	33.64
Sichuan	48.511	3.221	2.541	15.706	3.380	1.889	67.62	−4.94	25.66
Guizhou	20.791	5.393	6.796	10.676	7.700	6.186	48.65	−42.78	8.98
Yunnan	27.886	4.610	3.947	13.260	4.707	4.027	52.45	−2.10	−2.03
Xizang	56.693	0.744	0.458	19.696	0.428	0.294	65.26	42.47	35.81
Wshanxi	27.561	3.164	2.953	13.700	4.069	2.076	50.29	−28.60	29.70
Gansu	24.494	6.197	3.279	12.097	4.926	2.951	50.61	20.51	10.00
Qinghai	37.359	6.718	3.182	21.515	9.415	4.248	42.41	−40.15	−33.50
Ningxia	93.469	12.415	3.139	46.287	34.381	5.192	50.48	−176.93	−65.40
Xinjiang	20.853	4.664	1.347	15.154	5.552	2.334	27.33	−19.04	−73.27

Industrial waste water is given ten thousand tons per one hundred million RMB, industrial waste gas is given one hundred million standard cube per one hundred million RMB, solid waste is given tons per hundred million RMB. All ratios are shown as percentages. The material originates from calendar year *China Environment Yearbook* and *China Statistical Yearbook*

collected from the Shenzhen Stock Exchange (http://www.szse.cn/) and Shanghai Stock Exchange websites (http://www.sse.com.cn/). Pollution control-related data were collected from *China Environment Yearbook* from 2007 to 2011. Economic development-related data were collected from *China Statistical Yearbook* from 2007 to 2011 and from *Statistical Yearbook* of various provinces. Our final sample consisted of 155 observed values.

Variable Definition

We used main pollutant emissions to measure the performance of pollutant discharge reduction based on the studies of Jiang and McKibbin (2002) and Koehler and Spengler (2007). To reduce the influence of outliers, we chose the logarithm of emissions (EM) of the "three wastes" in unit industrial GDP as the variable. The "three wastes" were wastewater, waste gas, and solid waste.

The transparency of listed companies needs to be evaluated by an information disclosure indicator (Cheung et al. 2010). To measure the environmental information disclosure quality of listed companies in provinces and examine its effectiveness in pollutant discharge reduction, the annual reports of listed companies were analyzed to develop an environmental information disclosure indicator (*INF*) to serve as an explanatory variable. The general rule of environmental information disclosure ratings of various listed companies is 0 for no information disclosure, 1 for qualitative information disclosure, and 2 for quantitative information disclosure. The total score of listed companies in environmental information disclosure divided by the total number of listed companies in industry and public service in one area is the *INF*.

To minimize the impact of the possible omission of other influencing factors on empirical results, the following three groups of control variables were used.

The first group of control variables comprised other institutional emission reduction tools, including command control, market-based, and information-based tools. Among traditional command control tools, the improvement of environmental protection acts (*CRI*) balances negative externality and reduces the adverse selections of enterprises (Baumol and Oates 1988; Robert 2009). Similarly, the administrative penalty of polluting enterprises (*SAC*) can reduce excessive waste emissions (Dasgupta et al. 2001; Jiang and McKibbin 2002; Wang and Wheeler 2005). Among market-based tools, sewage charge (*CH*) is considered as an effective emission reduction measure in China (Wang 2002; Wang and Jin 2007). Emission permit trading (*TRA*) is not widely used in China. We constructed a dummy variable to analyze the effects of *TRA* on *local* pollution control. In addition to *INF*, we selected the environmental complaint status (*CO*) of each province as a measure indicator of information-based tools because studies showed that the environmental awareness of the community and the petitions of residents can facilitate pollution control (Wu 2010).

The second group of control variables was formed by non-institutional emission reduction tools. According to *the Twelfth Five-Year Plan of Energy Conservation and Emission Reduction* promulgated by the Chinese Government, measures of energy conservation and emission reduction include institutional, project, structural, and technical emission reduction. Among project emission reduction tools, we chose the government's public investment in pollution control (*IN*) as a measurement index because investment in environmental protection is positively correlated with pollution control (Lin et al. 2012). Among structural emission reduction tools, the number of closed and migrated dirty plants (*CLO*) was taken as a measurement index. Among technical emission reduction measures, the number of patent applications for environmental protection (*PAT*) was selected as a measurement index. The above aspects did not have empirical evidence based on the Chinese situation. However, as a development plan and overall arrangement of energy conservation and emission reduction in China, these measurement indices influence pollution control in China.

Finally, we added intrinsic factors to the regression model that may influence pollutant emission in different provinces. First, the proportion of state-owned enterprises (*STA*) is the ratio of the number of employees in state-owned enterprises of the industrial sector to the number of all employees of the industrial sector. Wang and Jin (2007) showed that compared with private enterprises, state-owned enterprises in China have worse environmental performance. The greater the proportion of state-owned enterprises, the poorer the local environmental quality. Second, the level of economic development (*ECL*) is the ratio of per capita GDP to the mean per capita GDP in different provinces. According to the Kuznets curve, areas with high levels of economic development often have superior environmental quality (Grossman and Krueger 1995). Third, foreign direct investment (*FDI*) is the ratio of stocks by foreign direct investment to regional GDP. Foreign direct investment affects the regional environment

Table 3 Definitions of variables

Variable	Description	Definition
EM	Pollutant discharge level	Quantity of pollutants discharged/regional industrial GDP
INF	Environmental information disclosure	$\sum$ score of environmental information disclosure of regional listed companies/number of listed companies in industrial and public service sectors in localities
CRI	Acts of environmental protection	Promulgated environmental laws, regulations, and standard numbers of the year
SAC	Environment administrative punishment	Number of cases of environmental administrative punishment decisions of the year
CH	Sewage charge	Collected sewage charges of diverse pollutants/corresponding pollutant emissions in industrial sector
TRA	Emission trading system	Areas implementing pollutant emission trading system are marked 1; otherwise, they are marked 0
CO	Environmental complaints	Visits on diverse pollutants
IN	Public investment in pollution control	Total investment of diverse pollutant control programs of the year
CLO	Number of closed and migrated dirty enterprises	Number of closed and migrated dirty enterprises of the year
PAT	Number of environment protection patents	Number of authorized environmental protection patents of the year
STA	Proportion of state-owned enterprises	Proportion of state-owned enterprises of all employees in industrial sector
ECL	Economic development level	Proportion of per capita GDP in mean per capita GDP in localities of same term
FDI	Foreign direct investment	Proportion of stocks of foreign direct investment in regional GDP

Table 4 Descriptive statistics

Variable	Obs.	Mean	SD	Max.	Median	Min.
*LogEM-w**	155	1.705	1.804	2.061	1.857	0.477
*LogEM-g**	155	1.214	1.192	1.536	1.263	−0.369
*LogEM-r**	155	0.553	0.034	0.832	0.560	−0.559
INF	155	0.487	0.361	1.155	0.453	0.047
CRI	155	0.226	0.658	7	1	0
SAC	155	548.923	854.335	31,246	689	0
CH-w	155	0.377	0.0984	1.234	0.310	0.051
CH-g	155	4.335	1.027	10.22	53.681	1.327
CH-r	155	0.454	0.312	1.087	0.568	0.171
TRA	155	0.162	0.251	1	0	0
CO-w	155	368.716	356.232	2,315	499	2
CO-g	155	498.652	412.334	1,896	506	3
CO-s	155	40.234	17.898	151	45	0
IN-w	155	48752.664	10121.556	331316.200	36811.00	1200.100
IN-g	155	68964.210	78541.134	206440.800	50109.300	142.300
IN-r	155	7759.767	6856.975	42266.73	8363.100	0
CLO	155	12.364	18.655	1500	14	0
PAT	155	0.291	0.374	39	1	0
STA	155	0.445	0.112	0.787	0.435	0.208
ECL	155	1	0.705	5.432	1.124	0.435
FDI	155	0.278	0.432	0.576	0.303	0.056

-w, *-g*, and *-r* represent wastewater, waste gas, and solid waste, respectively

quality in China (Kang and Liu 2009; Bao et al. 2011). The variables are defined in Table 3.

Descriptive Statistics

The descriptive statistics of main variables are shown in Table 4. For the *INF* of listed companies, the mean value was 0.487, standard deviation was 0.361, the maximum value was 1.155, and the minimum was 0.047, indicating substantial gaps in environmental information disclosure levels among listed companies in 31 Chinese provinces. Similarly, Table 4 presents a non-equilibrium emission of the "three wastes" in various provinces. Whether such non-equilibrium emission of the "three wastes" was caused by the differences in information disclosure degrees was tested in later multivariate analysis.

The results of the Pearson correlation analysis of major variables in the model are shown in Table 5. The correlation coefficient of each explanatory variable was smaller than 0.35, indicating a weak correlation among explanatory variables. Multicollinearity was low.

Empirical Results

We take multiple regression analysis without interaction terms and with interaction terms, respectively, to test the research hypotheses.

Multiple Regression Analysis Without Interaction Terms

The correlation between environmental information disclosure and pollutant discharge reduction was investigated by using the following multiple regression analysis model:

$$\begin{aligned} LogEM_{it} =& \alpha + \beta_1 INF_{it-1} + \beta_2 CRI_{it} + \beta_3 SAC_{it} \\ & + \beta_4 CH_{it} + \beta_5 TRA_{it} + \beta_6 CO_{it} + \beta_7 IN_{it} \\ & + \beta_8 CLO_{it} + \beta_9 PAT_{it} + \beta_{10} STA_{it} \\ & + \beta_{11} ECL_{it} + \beta_{12} FDI_{it} + \varepsilon_{it} \end{aligned} \quad (1).$$

Since the annual reports of listed companies were disclosed in the following year, the value of *INF* was lagged for one term. *i* and *t* represent the provinces and time, respectively.

The applied panel data model was tested by the likelihood ratio of the redundant variables of fixed effects to compare the mixed regression and fixed-effects models. According to the calculation, the corresponding probabilities of *F-statistics* and *LR-statistics* were very small, implying that the mixed regression model was invalid compared with the variable intercept model of fixed effects. Therefore, we selected the fixed effects model.

The regression results of model (1) are shown in Table 6. The *INF* coefficients of the three models of the emission reduction of wastewater, waste gas, and solid waste were negative. However, *INF* failed the test of

Table 5 Correlation analysis of main variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(1) *LogEM-w*	1.00																				
(2) *LogEM-g*	0.28	1.00																			
(3) *LogEM-r*	0.15	−0.21	1.00																		
(4) *INF*	−0.06	0.12	−0.17	1.00																	
(5) *CRI*	0.22	0.20	0.42	0.11	1.00																
(6) *SAC*	0.12	0.17	0.27	0.09	0.23	1.00															
(7) *CH-w*	0.01	0.08	0.13	−0.1	0.17	0.33	1.00														
(8) *CH-g*	0.06	0.21	0.16	0.33	0.15	0.20	0.01	1.00													
(9) *CH-r*	0.30	0.11	0.10	0.25	0.24	0.09	0.18	−0.33	1.00												
(10) *TRA*	0.06	0.15	0.04	0.18	0.04	−0.1	0.22	0.26	0.02	1.00											
(11) *CO-w*	0.13	0.15	0.04	0.27	0.09	0.28	0.24	0.03	0.24	0.14	1.00										
(12) *CO-g*	0.13	0.15	0.03	0.28	0.19	0.36	0.01	0.33	0.12	0.28	0.17	1.00									
(13) *CO-s*	0.26	0.14	0.06	0.25	0.19	0.23	0.06	0.05	0.22	0.27	0.13	0.05	1.00								
(14) *IN-w*	0.22	0.25	0.03	−0.3	0.32	0.08	0.24	0.32	0.17	0.18	0.35	0.11	0.06	1.00							
(15) *IN-g*	0.12	0.26	0.31	0.24	0.02	0.17	0.32	0.17	0.14	0.04	0.05	0.18	0.24	0.08	1.00						
(16) *IN-r*	0.18	0.33	0.14	0.02	0.17	0.32	0.01	0.18	0.25	0.17	0.33	0.18	0.29	0.15	0.24	1.00					
(17) *CLO*	0.31	0.05	0.21	0.06	0.21	0.18	0.17	0.10	0.04	0.09	0.30	0.24	0.04	0.14	0.28	0.19	1.00				
(18) *PAT*	−0.13	0.11	0.05	0.21	0.15	0.26	0.31	0.18	0.14	0.05	0.16	0.31	0.02	0.11	0.29	0.07	0.13	1.00			
(19) *STA*	0.21	0.10	0.32	0.20	0.08	−0.19	0.28	0.31	0.11	0.14	0.09	0.25	0.08	0.07	0.02	0.10	0.25	0.12	1.00		
(20) *ECL*	0.21	0.16	0.28	0.17	0.24	0.25	0.07	0.29	0.10	−0.03	0.35	0.21	0.21	0.08	0.22	−0.11	0.13	0.10	0.32	1.00	
(21) *FDI*	0.27	0.18	0.07	0.06	0.20	0.04	0.01	0.27	0.03	0.24	0.07	0.08	0.29	−0.19	0.06	0.26	0.23	0.13	0.16	0.15	1.00

Table 6 Results of multiple regression analysis without interaction terms

	LogEM-w	*LogEM-g*	*LogEM-r*
C	1.284 (0.365)	2.369 (0.985)	0.808 (1.198)*
INF	−0.002 (0.051)	−0.032 (0.217)	−0.136 (0.396)
CRI	−0.078 (1.014)	0.198 (0.896)	−0.456 (0.632)
SAC	−0.224 (8.369)***	−0.587 (7.654)***	−1.124 (6.621)***
CH-w	−0.385 (10.236)***		
CH-g		−0.851 (14.325)***	
CH-r			−0.489 (3.696)***
TRA	−0.113 (0.002)	0.021 (0.147)	−0.695 (0.704)
CO-w	−0.782 (1.561)*		
CO-g		0.814 (1.036)	
CO-r			0.325 (0.438)
IV-w	−0.002 (5.689)**		
IV-g		−0.041 (9.325)***	
IV-r			−0.073 (11.236)***
CLO	−1.315 (11.366)***	−1.287 (4.656)***	−0.355 (7.958)***
PAT	−0.036 (0.254)	−0.689 (0.112)	0.059 (0.214)
STA	1.302 (2.011) **	1.854 (1.107)	−0.136 (0.036)
ECL	−0.546 (1.178)	−0.687 (3.987) ***	−1.102 (2.684)***
FDI	0.008 (3.68) ***	0.171 (1.987)**	0.002 (1.856)**
Adj-R^2	0.758	0.701	0.796

Contents in brackets are *t* values

* $p < 0.1$; ** $p < 5$ %; *** $p < 0.01$

significance because of a small *t* value, demonstrating the weak negative correlation between environmental information disclosure and the emission of industrial pollutants, which in turn provides the supports for hypothesis 1. The *SAC* and *CH* coefficients in institutional emission reduction measures were negative, showing significance at the 1 and 5 % levels, respectively. *IV* in project emission reduction measures was negative, indicating significance at the 1 and 5 % levels. *CLO* in structural emission reduction measures was negative, showing significance at the 1 % level. Other variables failed the test of significance. The analysis results in Table 6 demonstrate that institutional, project, and structural emission reduction tools effectively control major industrial pollutants.

During the Eleventh Five-Year Plan period, the institutional measures positively affected the emission reduction of the "three wastes" in China. For example, every 10,000 RMB increase of *SAC* reduced pollutant discharge by at least 0.224 %; every 10,000 RMB increase of *CH* reduced pollutant discharge by at least 0.385 %. Effective institutional factors are traditional command control and market-based tools, which are mainly implemented by penalties and charging. However, the emission permit trading promoted in developed countries remained ineffective in China in terms of emission reduction. This finding is consistent with previous research results (e.g., Dasgupta et al. 2001; Wang and Wheeler 2003, 2005; Wang and Jin 2007). Hypothesis-related test results demonstrated that information-based tools only slightly affect the emission reduction of the "three wastes." *INF*, in particular, failed the test of significance. Blackman (2010) found that expectations of pollution control effects by environmental information disclosure in developing countries cannot be highly appraised because of the weak non-regulatory factors of pollutant discharge reduction, as well as the limited flow of environmental information. Based on empirical evidence in China, this paper supplements and improves the view of Blackman.

In Table 6, the influences of main variables on the emission of the "three wastes" are basically the same, reflecting the robustness of the model.

Results of Regression Analysis with Interaction Terms

Regulatory pressure is one of the conditions for a sound functioning of environmental information disclosure (Brouhle et al. 2009). Enterprises disclose environmental information because they believe that stricter regulations will be issued if they do not disclose environmental information (Lyon and Maxwell 2002; Koehler 2008). Command control and information-based tools can be integrated as complementary policy tools to improve the environmental performance of enterprises (Foulon et al. 2002). Therefore, a multiple regression analysis model with interaction terms was established.

Table 7 Results of multiple regression analysis with interaction terms

	LogEM-w		*LogEM-g*		*LogEM-r*	
C	1.352 (0.105)	0.532 (0.944)	1.231 (0.443)	0.464 (1.041)	−0.969 (0.053)	−1.434 (1.439)
INF	−0.101 (0.765)	−0.568 (0.598)	−0.245 (0.883)	−0.418 (1.086)	−0.786 (0.251)	−0.928 (0.733)
CRI	−0.077 (1.12)	−0.362 (0.484)	0.423 (0.141)	0.738 (0.081)	−0.359 (0.988)	−0.587 (1.100)
SAC	−0.853 (5.638)***	−0.268 (7.771)***	−0.538 (2.534)**	−0.345 (5.130)***	−0.681 (1.977)**	−0.451 (4.423)***
*INF*CRI*	0.078 (0.564)		0.743 (0.923)		0.112 (0.072)	
*INF*SAC*		0.308 (5.968)***		0.526 (4.570)***		0.197 (2.347)**
CH-w	−0.406 (1.879)*	−0.019 (2.381)**				
CH-g			−0.297 (2.409)**	−0.111 (2.062)**		
CH-r					−0.718 (8.728)***	−0.400 (3.911)***
TRA	−0.089 (0.609)	−0.327 (0.300)	0.170 (1.654)*	0.197 (0.468)	−0.909 (0.030)	−0.626 (1.102)
CO-w	−0.369 (0.654)	−0.138 (0.503)				
CO-g			−0.310 (0.010)	−0.477 (0.773)		
CO-r					−0.599 (0.623)	−0.184 (0.402)
IV-w	−0.004 (5.897)***	−0.049 (2.138)**				
IV-g			−0.203 (4.665)***	−0.380 (3.878)***		
IV-r					−0.234 (2.949)***	−0.351 (2.588)***
CLO	−0.734 (10.876)***	−0.770 (9.930)***	−0.949 (4.593)***	−0.670 (5.455)***	−0.129 (3.539)***	−0.568 (2.437)**
PAT	0.039 (0.783)	0.103 (0.673)	−0.639 (0.037)	−0.324 (1.100)	−0.250 (0.323)	−0.092 (0.029)
STA	1.016 (0.522)	0.845 (1.011)	1.291 (6.532)***	3.521 (3.564)***	−1.001 (0.002)	0.589 (0.104)
ECL	−0.427 (0.587)	−0.513 (2.145)*	−1.124 (7.847)***	−0.752 (10.258)***	−0.361 (4.444)***	−0.521 (2.411)**
FDI	0.003 (3.989***)	0.008 (3.477)***	0.058 (4.454)***	0.021 (1.804)*	0.027 (3.654)***	−0.501 (0.107)
Adj-R^2	0.799	0.808	0.776	0.754	0.810	0.814

Contents in brackets are *t* values

* $p < 0.1$; ** $p < 5\ \%$; *** $p < 0.01$

$$\begin{aligned} LogEM_{it} = \alpha &+ \beta_1 INF_{it-1} + \beta_2 CRI_{it} + \beta_3 SAC_{it} \\ &+ \beta_4 INF_{it-1} \times CRI_{it} + \beta_5 INF_{it-1} \times SAC_{it} \\ &+ \beta_6 CH_{it} + \beta_7 TRA_{it} + \beta_8 CO_{it} + \beta_9 IN_{it} \\ &+ \beta_{10} CLO_{it} + \beta_{11} PAT_{it} + \beta_{12} STA_{it} \\ &+ \beta_{13} ECL_{it} + \beta_{14} FDI_{it} + \varepsilon_{it}. \end{aligned} \quad (2)$$

The regression results of model (2) are shown in Table 7. With the introduction of interaction terms, *INF* remained insignificant in the three models. *SAC* showed significance at the 1 or 5 % level. *CR* was insignificant. Meanwhile, the *INF* × *SAC* coefficient was positive, indicating significance at the 1 % level. This result indicated that the interaction of environmental information disclosure and environmental administrative punishment significantly reduced the emission reduction of the "three wastes."

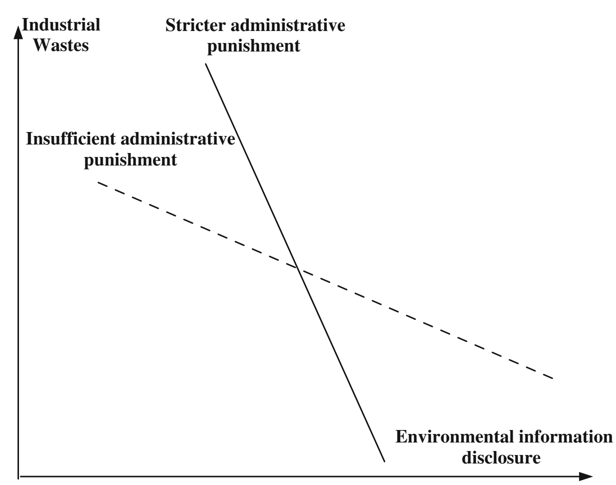

Fig. 1 Gradient diagram of interaction terms of environmental administrative punishment

Figure 1 shows the interaction between environmental information disclosure and environmental administrative punishment. Areas with insufficient environmental administrative punishment have weaker negative correlation between environmental information disclosure and the emission of the "three industrial wastes." However, areas with stricter environmental administrative punishment have significant negative correlation between environmental information disclosure and the emission of the "three industrial wastes."

Table 7 demonstrates that environmental information disclosure fails to achieve the expected emission reduction in China. Confronted with the continuous external pressure of regulation and penalties from supervising agencies, regulated enterprises tend to accept the environmental information disclosure system to express their willingness to reduce pollutant emission and improve pollutant control to present their positive obedience to external environment regulation through self-reports and illegal behavior correction. Environmental information disclosure is a hygiene factor of pollutant discharge reduction rather than an incentive factor. The effectiveness of environmental information disclosure depends on regulatory pressure. The emission reduction effects of environmental information disclosure are enhanced with the increase of environmental administrative punishment.

Further Content Analysis

Why did environmental information disclosure not achieve the expected effects of pollutant discharge reduction in China? To answer this question, information on environmental information disclosure needed to be further analyzed. In this section, we conducted a content analysis to quantify environmental information disclosure. As a structural approach to analyze textual materials, content analysis transforms natural information in unstructured texts into structured information that can be used for quantitative analysis by using a series of transformation paradigms (Harwood and Garry 2003). Content analysis includes category setting, material codes, credibility testing, and analysis summary.

Category Setting and Material Codes

Listed companies in Jiangsu Province were selected for content analysis for two reasons. First, located in the Yangtze River Delta region of China, Jiangsu has the fastest economic growth in China. Jiangsu is a demonstration area of eco-efficiency improvement to relieve the pressure on resources and environment. It is a representative province in China. Second, Jiangsu not only ranks among the top three provinces with the most listed companies but is also one of the leading provinces in environmental information disclosure. These characteristics are convenient for data collection and analysis.

Jose and Lee (2007) found that natural coding is selected in accordance with the principles of detail, independence, and mutual exclusiveness. Expressions related to environmental information in the annual reports of listed companies were selected as keywords. Pivotal information of generality was extracted from the samples. Contents of environmental information disclosure were quantized and labeled. The system of categories is shown in Table 8.

Table 8 Category system of environmental information disclosure

Number	Category	Definition of characteristics
1	Environmental policies	Enterprises should undertake the vision and mission of environmental protection responsibility, environmental protection policy, and annual environmental goals, as well as the development and implementation of environment-friendly strategies
2	Environmental risks	This category refers to the evaluation of national environmental laws and regulations that bring policy risks to enterprises, challenges of environmental constraints for corporate finance, and other operations, as well as the possibility of investigation or punishment of enterprises because of violations in regulations from environmental protection authorities
3	Environmental inputs	This category includes corporate environmental investments (capital expenditures of equipment upgrading or re-purchasing for pollutant discharge reduction), expenditures incurred in environmental protection (R&D expenses, sewage charges, environmental management fees, and green fees disclosed in financial statements)
4	Environmental management	Major environmental protection measures taken during the reporting period; certifications of ISO14000, HSE, GB/T2400, and other environmental management systems; and environmental protection measures during engineering project processing, environmental education, and training
5	Environmental liabilities	Energy consumption per unit of output, total water consumption, total amount of standard coal, wastewater emissions, SO_2 emissions, CO_2 emissions, fume and dust emissions, and industrial solid waste per unit of output
6	Environmental performance	Honorary titles related to environmental management, emission reduction of main pollutants, and the decline of energy consumption and water conservation

We then ranked the environmental information disclosure of sample companies with respect to quantity and quality. The ranking of information disclosure quantity was in accordance with Shen and Li (2010). Lines related to the six categories in the annual reports of sample companies were obtained as the amount.

The ranking of information disclosure quality was in accordance with Niskala and Pretes (1995), and Jose and Lee (2007). Three dimensions (disclosure carrier, disclosure form, and disclosure term) were selected for the evaluation. The evaluation was based on the following criteria:

(1) Disclosure carrier. No disclosure in any carrier was denoted as 0, disclosure in non-financial parts of annual reports was denoted as 1, disclosure in financial parts of annual reports was denoted as 2, and disclosure in both non-financial and financial parts was denoted as 3.
(2) Disclosure form. No disclosure in any form was denoted as 0, disclosure by qualitative description in texts was denoted as 1, disclosure of quantitative data or monetized information was denoted as 2, and data analysis based on quantitative disclosure was denoted as 3.
(3) Disclosure term. No disclosure of information related to time was denoted as 0, disclosure of current situation was denoted as 1, disclosure of future situation was denoted as 2, and disclosure of current and future situations was denoted as 3.

Therefore, the range of each quality dimension was [0–3]. The range of quality of each disclosed item was [0–9].

Credibility Test

To measure the range of the categorization of environmental information disclosure and scoring coder credibility, we adopted Cohen's K coefficient method to test credibility. Based on experience, when K exceeded 0.69, we can "reasonably" believe that an indicator passed the credibility test (Kvalseth 1991).

Ten annual reports of listed companies were randomly selected, and their environmental information disclosure was scored independently by four participants on the basis of their understanding of category characteristics and scoring rules. The scoring results were tested in terms of consistency. The intrinsic consistency was 0.935. After 4 weeks, they were scored again with the same approach by the same participants. Two scoring results were compared, showing that the extrinsic consistency was 0.914. The results are shown in Table 9. Therefore, the above categorization and scoring rules were applicable in this paper.

Table 9 Results of credibility test

Credibility type	Comprehensive consistency coefficient (K)
Credibility of intrinsic consistency	0.935 ($n = 40$)
Credibility of extrinsic consistency	0.914 ($n = 40$)

Results of Content Analysis

By the end of the "Eleventh Five-Year Plan" period, Jiangsu Province had a total of 201 listed companies in A stock markets. Among them, 158 were in the industry and public service sectors. *Panel A* in Table 10 shows the overall situation of listed companies in Jiangsu Province during the "Eleventh Five-Year Plan" period. The information disclosure of listed companies focused on environmental performance, accounting for 65.26 % of all information disclosed by sample companies on average, followed by environmental management (53.27 %), environmental inputs (26.20 %), and environmental policies (19.72 %). The number of listed companies that disclosed these three items increased during the Eleventh Five-Year Plan period. Environmental liabilities were less significantly disclosed, accounting for 11.12 % of sample companies. Environmental risks were the least significantly disclosed information, accounting for 2.87 % of sample companies. According to the mean value, environmental information disclosure did not present significant difference among years but showed significant differences among different categories.

Panel B in Table 10 shows the quantity of the disclosed environmental information categories of listed companies in Jiangsu Province. First, the items of each listed company in Jiangsu Province disclosed in each category were ranked. Second, the mean scores of six categories were calculated. In *Panel B*, during the Eleventh Five-Year Plan, the line amount of each category of environmental information disclosed by listed companies increased in both range and mean value. The mean value indicated that the amount of information disclosure increased significantly during the Eleventh Five-Year Plan.

In terms of specific categories, environmental management was the most significantly disclosed, followed by environmental policies. The mean values of disclosed items in annual reports were 3.392 and 3.202. Most listed companies disclosed the targets of environmental protection, adopted environmental protection measures, and discussed the implementation of environmental protection laws and regulations in the director's report. Environmental risks were the least significantly disclosed, with a mean value of only 1.07. Environmental liabilities were also less significantly disclosed as 1.696. These contents consisted a very limited part of annual reports and were only mentioned casually. According to the mean values, the disclosed amount of each category showed significant difference.

Table 10 Content analysis of environmental information disclosure of listed companies in Jiangsu Province during Eleventh Five-Year Plan

Panel A: General status of information disclosure of listed companies in Jiangsu Province

Item	2006	2007	2008	2009	2010	Average
Environmental policies						
Proportion (%)	14.07	18.56	20.13	22.78	23.06	19.72
Amount	15	22	26	33	36	27
Environmental risks						
Proportion (%)	3.08	2.59	2.89	2.77	3.01	2.87
Amount	3	3	4	4	5	4
Environmental inputs						
Proportion (%)	21.78	23.58	26.07	28.67	30.88	26.20
Amount	24	28	34	41	49	35
Environmental management						
Proportion (%)	44.56	48.59	53.08	58.08	62.05	53.27
Amount	48	58	69	83	98	71
Environmental liabilities						
Proportion (%)	10.78	10.99	11.03	11.14	11.67	11.12
Amount	12	13	14	16	18	15
Environmental performance						
Proportion (%)	57.08	59.07	66.34	70.33	73.46	65.26
Amount	62	70	87	101	116	87
P value (year-to-year, ANOVA test)	0.971					
P value (item-to-item, ANOVA test)	0.000					

Panel B: Quantity of six items in information disclosure of listed companies in Jiangsu Province

Item	2006		2007		2008		2009		2010		Average
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
Environmental policies	0–7	2.34	0–7	2.42	0–10	3.68	0–11	3.77	0–10	3.88	3.218
Environmental risks	0–3	0.87	0–2	1.01	0–3	1.11	0–3	1.17	0–3	1.29	1.090
Environmental inputs	0–8	2.34	0–6	2.46	0–10	3.26	0–10	3.32	0–10	3.45	2.966
Environmental management	0–11	2.68	0–12	2.7	0–14	3.82	0–15	3.88	0–14	3.95	3.406
Environmental liabilities	0–4	1.07	0–5	1.09	0–7	2.08	0–6	2.1	0–6	2.32	1.732
Environmental performance	0–6	1.08	0–7	1.12	0–10	2.56	0–11	2.67	0–10	2.89	2.064
Total	0–11	1.73	0–12	1.80	0–14	2.75	0–15	2.82	0–14	2.96	2.410
P value (year-to-year, ANOVA test)	0.082										
P value (item-to-item, ANOVA test)	0.000										

Panel C: Quality of six items in information disclosure of listed companies in Jiangsu Province

Item	2006		2007		2008		2009		2010		Average
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
Environmental policies	0–9	2.87	0–9	2.99	0–9	3.02	0–9	2.55	0–9	2.80	2.84
Environmental risks	0–9	1.01	0–9	1.28	0–9	1.13	0–9	1.35	0–9	1.18	1.19
Environmental inputs	0–9	4.45	0–9	4.21	0–9	4.01	0–9	4.16	0–9	4.27	4.22
Environmental management	0–9	3.20	0–9	3.32	0–9	3.01	0–9	3.88	0–9	3.54	3.39
Environmental liabilities	0–9	2.88	0–9	2.65	0–9	2.39	0–9	2.45	0–9	2.39	2.55
Environmental performance	0–9	3.25	0–9	3.65	0–9	3.18	0–9	3.23	0–9	3.82	3.43
Total	0–9	2.94	0–9	3.02	0–9	2.79	0–9	2.93	0–9	3.00	2.94
P value (year-to-year, ANOVA test)	0.996										
P value (item-to-item, ANOVA test)	0.000										

Panel C in Table 10 reflects the quality of six categories of environmental information disclosed by listed companies in Jiangsu Province. First, the quality of each category of environmental information disclosed by each sample company was ranked. The mean value of the quality scores of six categories in all sample companies was calculated. According to *Panel C*, the range and mean value of each category of environmental information disclosed by listed companies in Jiangsu Province were comparatively low and rarely changed during the Eleventh Five-Year Plan period.

Viewed from specific categories, environmental risks were of the poorest quality, whereas environmental inputs had the best quality because environmental risks were disclosed only in the non-financial part of annual reports mainly through qualitative verbal description. However, environmental inputs were disclosed in both non-financial and financial parts of annual reports. Moreover, comparative analysis of expenses at the end and beginning of a year was available. In addition, environmental policies and liabilities were relatively low. The mean value revealed a substantial gap in the quality of disclosure among categories.

According to the results of content analysis, among listed companies in Jiangsu Province, environmental inputs, environmental performance, environmental management, and other categories beneficial to the image of listed companies were disclosed with relatively better quality. Meanwhile, categories such as environmental risks and liabilities that were not favorable to the listed companies were less significantly disclosed and showed poorer disclosure quality, which in turn provides the supports for hypothesis 2. A "selfish" tendency of selection was observed in environmental information disclosure, which was a form of "greenwashing."

Discussion and Conclusions

This paper conducted empirical studies by using provincial-level panel data from 2006 to 2010 (during the Eleventh Five-Year Plan period of China). We found that, as a developing country and an emerging market, China has benefited from institutional, project, and structural emission reductions in the area of pollution control. In terms of institutional factors, traditional command control and market-based tools, especially administrative penalties and sewage charges, remain to be key measures in pollution control. In the policy framework of pollution control in China, environmental information disclosure only slightly influenced the emission of the "three industrial wastes" in the Eleventh Five-Year Plan period. However, the interaction items of information disclosure and administrative penalties passed the test of significance. This finding is consistent with Brouhle et al.'s research using samples of the United States (Brouhle et al. 2009). As a new instrument of environmental policies, environmental information disclosure is based on two premises, namely, voluntary disclosure and self-regulation. However, this paper reports that self-regulation did not show exclusivity in the replacement of obligatory regulation. By contrast, the pressure of obligatory regulation is a key external factor of effective "self-regulation." The environmental information disclosure of listed companies in Jiangsu Province showed that during the Eleventh Five-Year Plan period, the proportion and amount of listed companies that disclosed environmental information, such as pollutant discharge reduction and other environmental information, increased obviously. However, they disclosed selected positive information (such as environmental performance and environmental inputs) or descriptive and ambiguous information (such as environmental management) but were reluctant to disclose information such as environmental risks and liabilities that might negatively affect them. Although some enterprises disclosed environmental information, the quality was generally unsatisfactory. This finding confirmed the view of Dye (2001) that "voluntary information disclosure is an exception in game theory. The subject of information disclosure only discloses positive information rather than negative ones."

As the ecological crisis intensifies and the population explosion and resource shortage, people no longer regard profit maximization as the only objective of a company's operation, as stated in New Classical Economics. Instead, the public call on companies to show their attention to social and environmental responsibilities. They require companies to advocate and practice ethical and moral principles in their business practices. Since the public, the consumers, consider it important, Corp-ethics has become such. British Co-Operative Wholesale Services sponsored research that has proven the rise of the "ethical" consumer campaign. This research, through a sample survey on 30,000 food retail consumers, has discovered that (1) 35 % of respondents, "have resisted purchasing some products out of concern for animal, environmental, or human rights"; (2) 60 % of respondents "will resist purchasing a product if no care for these problems are shown" (CWS 1995).

Corporate ethical philosophies for addressing social responsibilities include four types or responses: Reaction, Defense, Accommodation, and Pro-action (Carrol 1979). However, ideal ethical performance is seldom realized through self-organization. It is often shown in a stimulus–response model (Huang and Zhao 2010). First, an external stimulus which does not create a conflict with corporate aspirations of financial performance and the undertaking of social responsibilities like environmental protection, etc., forms through the making, releasing, and revision of public policies. Companies aiming at this stimulus factor select their own plan for responding to these social responsibilities to obtain the "carrot" of positive feedback and avoid the "big stick" of negative feedback. This stimulus aims to force companies to realize long-term benefits depend upon the sustainable development of the environment. Second, corporations produce adaptive behavior as a reaction to learning from stimulus and will form environmentally friendly new rules by basing them upon their own strategy, culture, systems, industrial flow, and technology. In developed countries, the current incentive and restraint mechanism brought about by formal and informal regulation has produced results, while in China and other developing countries, the stimulus mechanism should be strengthened by perfecting management and company policy.

This research has important implications and guidelines for China and other emerging market countries. In environmental regulations, from the aspect of management, different regulatory tools have potential effectiveness which may solve different environmental issues (Stavins 1996). The application of one regulation tool does not exclusively replace the other. On the contrary, combining different regulation tools may achieve better effects (Foulon et al. 2002; Kathuria 2006). In China, for instance, the emission reduction performance of environmental information disclosure is subject to the intensity of regulatory pressure. Therefore, traditional corporate command control tools are essential and should be enhanced when necessary. Moreover, the combination of command control and information-based tools is effective in improving pollution control. Environmental Management Department and Securities Management Department in China should establish a joint supervision mechanism, and punitive actions against the corporations from the list should be taken when a failure to disclose noticeable environmental impact events occurs in a timely manner. Although more listed Chinese companies are disclosing environmental information, from the aspect of policy making, corporations only want to accomplish the minimum requirements of regulatory supervisors and cater to public demand to avoid restriction and establish a good corporate image. Their actual emission reduction actions are non-existent. China must strengthen the environmental information disclosure of the listed companies. However, it should fulfill certain steps in policy design. The first is to perfect and tighten the laws on environmental information disclosure. China should revise the Environmental Protection Act, Securities Act, Company Act, and Accounting Act, to clarify the content and scope of corporate environmental information disclosure, and restrict the environmental information disclosure by law, but not departmental regulation. The second is the development of environmental accounting standards. China should require the explanation of environmental assets, liabilities, costs, and expenses in accounting elements, compulsively require the open disclosure of such information, and make environmental accounting normative and exercisable. The third step would be to establish an environmental audit system aimed at the listed companies. An effective audit system may prevent the "greenwashing" behavior of the companies with poor environmental performance in their information disclosure. Environmental information disclosure lays a foundation for the implementation of an environmental audit. The development of the environmental audit would be helpful in enhancing the credibility of information disclosure. In order to attest to the authenticity, compliance and fairness of listed companies' environmental information disclosure, China should formulate the environmental audit standards and practice guidelines of listed companies, and meanwhile, strengthen the professionalism of environmental auditors.

We discuss these limitations and examine avenues for further research after summarizing our findings and their implications.

We developed our research methods for this paper by reconstructing the environmental information disclosure indicators. An analysis of each annual report of the listed companies was conducted to compensate for the lack of existing environmental disclosure data. In Tables 6 and 7, the main variables exhibited are consistent in terms of the function and the degree of influence on the discharging of the "three wastes" (waste gas, waste water, and solid waste), but we have no way to test the strength of these research findings by more scientific means. To make this research more robust, several methods can be explored. Constant efforts to perfect the listed companies' environmental information disclosure system within China and the intervention of a third party audit would assist in researchers' efforts in using more flexible methods in measuring the quality of information. It would also assist in the analysis of the effects of longer term pollution emission reduction performance in future research. While we have adopted a linear regression model, environmental problems may be nonlinear. They are open, regional, and dynamic. More complicated models may be applied in the future to consider such interactions and nonlinear relationships.

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References

Bao, Q., Chen, Y. Y., & Song, L. G. (2011). Foreign direct investment and environmental pollution in China: A simultaneous equations estimation. *Environment and Development Economics, 16*(1), 71–92.

Barker, T., & Kfhler, J. (1998). Equity and ecotax reform in the EU: Achieving a 10 per cent reduction in CO_2 emissions using excise duties. *Fiscal Studies, 19*(4), 375–402.

Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy*. Cambridge, England: Cambridge University Press.

Bemelmans-Videc, M. L., Rist, R. C., & Vedung, E. (1998). *Carrots, sticks and sermons: Policy instruments and their evaluation*. New Brunswick, NJ: Transaction.

Bennear, L. S., & Olmstead, S. M. (2008). The impacts of the "right to know": Information disclosure and the violation of drinking water standards. *Journal of Environmental Economics and Management, 56*(2), 117–130.

Blackman, A. (2010). Alternative pollution control policies in developing countries. *Review of Environmental Economics and Policy, 4*(2), 234–253.

Blackman, A., & Harrington, W. (2000). The use of economic incentives in developing countries: Lessons from international experience with industrial air pollution. *Journal of Environment and Development, 9*(1), 5–44.

Bohm, P. (1997). *The economics of environmental protection: Theory and demand revelation*. Cheltenham, UK: Edward Elgar.

Bressers, T. A., & Schuddeboom, J. (1994). A survey of effluent charges and other economic instruments in Dutch environmental policy. In *Applying economic instruments to environmental policies in OECD and dynamic non-member economies* (pp. 153–172). Paris: OECD.

Brouhle, K., Grifiths, C., & Wolverton, A. (2009). Evaluating the role of EPA policy levers: An examination of a voluntary program and regulatory threat in the metal-finishing industry. *Journal Environmental Economics and Management, 57*(2), 166–181.

Bruvoll, A., & Larsen, B. M. (2004). Greenhouse gas emissions in Norway: Do carbon taxes work. *Energy Policy, 32*(4), 493–505.

Carrol, A. B. (1979). A three-dimensional conceptual model of corporate performance. *Academy of Management Review, 4*(4), 497–505.

Cheung, Y. L., Jiang, P., & Tan, W. Q. (2010). A transparency disclosure index measuring disclosures: Chinese listed companies. *Journal of Accounting and Public Policy, 29*(3), 259–280.

CWS. (1995). *Responsible retailing*. Manchester, UK: Co-operative Whole Society.

Dasgupta, S., Bi, J., Wheeler, D., Wang, J. N., Cao, D., Lu, G. F., et al. (2004). Environmental performance rating and disclosure: China's GreenWatch program. *Journal of Environmental Management, 71*(2), 123–133.

Dasgupta, S., Laplante, B., Mamingi, N., & Wang, H. (2001). Inspection, pollution price, and environmental performance: Evidence from China. *Ecological Economics, 36*(3), 487–498.

Dasgupta, S., Wheeler, D., & Wang, H. (2007). Disclosure strategies for pollution control. In T. Teitenberg & H. Folmer (Eds.), *International yearbook of environmental and resource economics 2006/2007: A survey of current issues*. Northampton: Edward Elgar.

Dye, A. R. (2001). An evaluation of "essays on disclosure" and the disclosure literature in accounting. *Journal of Accounting and Economics, 32*(1), 181–235.

Foulon, J., Lanoie, P., & Laplante, B. (2002). Incentives for pollution control: Regulation or information? *Journal of Environmental Economics and Management, 44*(1), 169–187.

García, J. H., Afsah, S., & Sterner, T. (2009). Which firms are more sensitive to public disclosure schemes for pollution control? Evidence from Indonesia's PROPER program. *Environmental & Resource Economics, 42*(2), 151–168.

García, J. H., Sterner, T., & Afsah, S. (2007). Public disclosure of industrial pollution: The PROPER approach for Indonesia? *Environment and Development Economics, 12*(6), 739–756.

Garrod, N. (2000). Environmental contingencies and sustainable modes of corporate governance. *Journal of Accounting and Public Policy, 19*(3), 237–261.

Grossman, G. M., & Krueger, A. (1995). Economic growth and the environment. *Quarterly Journal of Economics, 110*(2), 353–377.

Harwood, T. G., & Garry, T. (2003). An overview of content analysis. *The Marketing Review, 3*(4), 479–498.

Hettige, H., & Wheeler, D. (1996). Determinants of pollution abatement in developing countries: Evidence from south and southeast Asia. *World Development, 24*(12), 1891–1904.

Huang, R. B., & Zhao, Q. (2010). The realization mechanism and path innovaion for Taihu Lake water pollution governance by means of environmental auditing. *China Soft Science, 25*(3), 66–73, 151.

Jiang, T. S., & McKibbin, W. J. (2002). Assessment of China's pollution levy system: An equilibrium pollution approach. *Environment and Development Economics, 7*(1), 75–105.

Jin, H. H., Qian, Y. Y., & Weingast, B. R. (2005). Regional decentralization and fiscal incentives: Federalism, Chinese Style. *Journal of Public Economics, 89*(9), 1719–1742.

Jordan, A., Wurzel, R. K. W., & Zito, A. R. (2003). 'New' instruments of environmental governance: Patterns and pathways of change. *Environmental Politics, 12*(1), 1–24.

Jose, A., & Lee, S. M. (2007). Environmental reporting of global corporations: A content analysis based on website disclosures. *Journal of Business Ethics, 72*(4), 307–321.

Joshi, S., Ranjani, K., & Lester, L. (2001). Estimating the hidden costs of environmental regulation. *The Accounting Review, 76*(2), 171–198.

Kang, Y. F., & Liu, Y. L. (2009). Environmental stringency and foreign direct investment inflows: Testing the pollution haven hypothesis in China. *Journal of International Business and Economics, 9*(3), 19–31.

Kathuria, V. (2006). Controlling water pollution in developing and transition countries: Lessons from three successful cases. *Journal of Environmental Management, 78*(4), 405–426.

Kathuria, V. (2009). Public disclosures: Using information to reduce pollution in developing countries. *Environment, Development and Sustainability, 11*(5), 955–970.

Khanna, M. (2001). Non-mandatory approaches to environmental protection. *Journal of Economic Surveys, 15*(3), 291–324.

Koehler, D. A. (2008). The effectiveness of voluntary environmental programs—A policy at a crossroads? *Policy Studies Journal, 35*(4), 689–722.

Koehler, D. A., & Spengler, J. D. (2007). The toxic release inventory: Fact or fiction? A case study of the primary aluminum industry. *Journal of Environmental Management, 85*(2), 296–307.

Kolstad, D. C. (1986). Empirical properties of economic incentives and command-and-control regulations for air pollution control. *Land Economics, 62*(3), 250–268.

Konar, S., & Cohen, M. (1997). Information as regulation: The effect of community right to know laws on toxic emissions. *Journal of Environmental Economics and Management, 32*(1), 109–124.

Kuo, L., Yeh, C. C., & Yu, H. C. (2012). Disclosure of corporate social responsibility and environmental management: Evidence from China. *Corporate Social Responsibility and Environmental Management, 19*(5), 273–287.

Kvalseth, T. O. (1991). A coefficient of agreement for nominal scales: An asymmetric version of Kappa. *Educational and Psychological Measurement, 51*(1), 95–101.

Lee, R. D. (1999). Lowering the cost of pollution control versus controlling pollution. *Public Choice, 100*(1/2), 123–134.

Li, W. X., Liu, J. Y., & Li, D. D. (2012). Getting their voices heard: Three cases of public participation in environmental protection in China. *Journal of Environmental Management, 98*(1), 65–72.

Li, H. B., & Zhou, L. A. (2005). Political turnover and economic performance: The incentive role of personnel control in China. *Journal of Public Economics, 89*(9), 1743–1762.

Lin, Q. H., Chen, G. Y., Du, W. C., & Niu, H. P. (2012). Spillover effect of environmental investment: Evidence from panel data at provincial level in China. *Frontiers of Environmental Science & Engineering, 6*(3), 412–420.

Lundqvist, L. J. (2001). Implementation from above: The ecology of Sweden's new environmental governance. *Governance—An International Journal of Policy Administration and Institutions, 14*(3), 319–337.

Lyon, T., & Maxwell, J. (2002). Voluntary approaches to environmental regulation: A survey. In M. Frazini & A. Nicita (Eds.), *Economic institutions and environmental policy*. Aldershot: Ashgate Publishing.

Lyon, T. P., & Maxwell, J. W. (2011). Greenwash: Corporate environmental disclosure under threat of audit. *Journal of Economics & Management Strategy, 41*(3), 3–41.

Maloney, T. M., & Bruce, Y. (1984). Estimation of the cost of air pollution control regulation. *Journal of Environmental Economics and Management, 11*(3), 244–263.

Meng, X. H., Zeng, S. X., & Tam, C. M. (2013). Whether top executives' turnover influences environmental responsibility: From the perspective of environmental information disclosure. *Journal of Business Ethics, 114*(2), 341–353.

Montes-Sancho, M. J., & Delmas, M. (2010). Information disclosure policies: Evidence from the electricity industry. *Economy Inquiry, 48*(2), 483–498.

Montinola, G., Qian, Y. Y., & Weigast, B. R. (1995). Federalism, Chinese style: The political basis for economic success in China. *World Politics, 48*(1), 50–81.

Niskala, M., & Pretes, M. (1995). Environmental reporting in Finland: A note on the use of annual reports. *Accounting, Organizations and Society, 20*(6), 457–566.

Nordberg-Bohm, V. (1999). Stimulating 'green' technological innovation: An analysis of alternative policy mechanisms. *Policy Sciences, 32*(1), 13–38.

OECD. (2007). *Environmental performance reviews: China*. Château de la Muette, Paris: Organization for Economic Co-operation and Development (OECD).

Powers, N., Blackman, A., Lyon, T. P., & Narain, U. (2011). Does disclosure reduce pollution? Evidence from India's Green Rating Project. *Environmental & Resource Economics, 50*(1), 131–155.

Ricky, Y. K. C., & Lorett, B. Y. L. (2000). Antecedents of green purchases: A survey in China. *Journal of Consumer Marketing, 17*(4), 338–357.

Robert, V. P. (2009). *Environmental regulation: Law, science, and policy*. Tex: Wolters Kluwer Law & Business.

Rock, M. T. (2002). Pathways to industrial environmental improvement in the East Asian newly industrializing economies. *Business Strategy and the Environment, 11*(2), 90–102.

Shen, H. T., & Li, Y. X. L. (2010). Environmental information disclosure of listed companies in China's heavy polluting industries. *Securities Market Herald, 17*(6), 51–57 (in Chinese).

Stavins, R. N. (1996). Correlated uncertainty and policy instrument choice. *Journal of Environmental Economics and Management, 30*(2), 218–232.

Tietenberg, T. (1998). Disclosure strategies for pollution control. *Environmental & Resource Economics, 11*(3), 587–602.

Uchida, T. (2007). Information disclosure policies: When do they bring environmental improvements? *International Advances in Economic Research, 13*(1), 47–64.

Wang, H. (2002). Pollution regulation and abatement efforts: Evidence from China. *Ecological Economics, 41*(1), 85–94.

Wang, H., & Jin, Y. H. (2007). Industrial ownership and environmental performance: Evidence from China. *Environmental & Resource Economics, 36*(3), 255–273.

Wang, H., & Wheeler, D. (2003). Equilibrium pollution and economic development in China. *Environment and Development Economics, 8*(3), 451–466.

Wang, H., & Wheeler, D. (2005). Financial incentives and endogenous enforcement in China's pollution levy system. *Journal of Environmental Economics and Management, 49*(1), 174–196.

World Bank. (1998). Five years after Rio: Innovations in environmental policy. Environmentally Sustainable Development Studies and Monographs Series No. 18. Washington, DC: World Bank.

Wu, Y. R. (2010). Regional environmental performance and its determinants in China. *China & World Economy, 18*(3), 73–89.

YCELP. (2013). The 2012 environmental performance index ranking. New Haven, CT: Yale Center for Environmental Law & Policy (YCELP).

Zeng, S. X., Xu, X. D., Dong, Z. Y., & Tam, V. W. Y. (2010). Towards corporate environmental information disclosure: An empirical study in China. *Journal of Cleaner Production, 18*(12), 1142–1148.